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The Journal of
Bone and Joint Surgery

SURGICAL OBLITERATION OF BONE CAVITIES FOLLOWING TRAUMATIC OSTEOMYELITIS

BY LIEUTENANT COLONEL MARVIN P. KNIGHT AND MAJOR GEORGE O. WOOD
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One of the most serious reconstruction problems in War casualties is the treatment of bone cavities associated with loss of skin and soft tissue, following infected compound fractures. Especially has difficulty been encountered in the handling of large bone defects in the tibia and the femur in the vicinity of the knee.

The destructive nature of war missiles results in severe loss of bone substance, followed by a varying degree of infection and dense scar formation. The bone cavity is reluctant to heal, and the tissue is subject to necrosis and recurrent inflammation. Furthermore, the bone is usually so weakened that full function cannot be resumed; and, even if union occurs, refracture is imminent unless the bone is reinforced by a graft. Bone-grafting is contra-indicated in the presence of granulation or scar tissue, and is hazardous without adequate skin coverage. In spite of the usual methods of closed plaster treatment, sequestration, and chemotherapy, a large depressed cavity persists with thin adherent scar and incomplete union. Some patients have required a permanent brace, while others have been subjected to a collapsing operation, with resultant shortening or even amputation.

The authors have adopted a procedure which expedites healing, and obliterates these cavities in the long bones of the extremities.

The program consists of early and complete sequestrectomy, followed ordinarily in about seven days by the application of a split-thickness skin graft as a dressing, applied meticulously into the depths of the saucerized area.

This procedure effectively converts the infected wound into a closed fracture, so that the wound remains healed and dry. However, there still remains a defect in the bone, which seriously impairs its strength, particularly important in the weight-bearing requirements of the lower extremity. Bone does not regenerate beneath these adherent split-thickness grafts, and the defect remains essentially the same size, in spite of the natural tendency of the soft tissue to contract. In most instances, at the time of bone-grafting, it has been found necessary to replace a split-thickness skin graft with a full-thickness graft by some plastic method, in order to ensure the success of the procedure.

In the past, attempts have been made to obliterate septic bone cavities by the introduction of antiseptic paste, preparatory to a pedicle graft of fat or muscle. Pedicle skin

grafts also have been introduced, in an effort to secure an epithelial covering without any attempt at obliteration of the cavities. The result of these efforts has been variable and frequently unsuccessful. In the present series, therefore, these cavities have first been thoroughly cleansed, then lined with split-thickness skin, which was later removed. Finally the cavities were obliterated by the application of the bone graft and simultaneous covering with stable full-thickness skin. Experience with a limited number of cases indicates that even severe lesions of this character can be cured by a three-stage program of (1) thorough sequestrectomy and excision of the scar, (2) early split-skin grafting, and, finally, (3) bone-grafting followed by the immediate application of a full-thickness pedicle skin graft.

DETAILS OF THE STAGES OF THE PROCEDURE

The First Stage: Sequestrectomy and Preparation of the Cavity

This first stage is planned and carried out so that the resultant wound will be adaptable to the early application of a split-thickness skin graft, and so that the final scars will be advantageously placed. All non-viable bone and bone of questionable viability should be removed; and the fracture site should be saucerized, so that granulation tissue will cover the bone surfaces. An attempt is made to preserve any union which may be present, but occasionally minimal fibrous union must be sacrificed. For obvious reasons, all cicatricial soft tissue in the region of the fracture is excised as completely as possible, and, in the event that a joint is involved in the osteomyelitic process, the cartilage is similarly removed. The wound is packed open with vaseline gauze, and the affected extremity is provided with plaster immobilization, pending subsequent operative procedures.

After five to seven days, the wound is inspected, and its suitability for skin-grafting is determined. Usually it is healthy with a very thin layer of granulation tissue overlying the bone surfaces; but occasionally, in those cases in which suppuration has been allowed to continue over a period of time sufficient to produce extensive soft-tissue fibrosis and bone sclerosis, the outward growth of granulations over the eburnated bone surfaces will probably be slow. In these cases, grafting must be deferred until the bone is covered with the minute granulations necessary for a successful skin-grafting. With the gradual accumulation of experience, the saucerization stage can be improved so that this difficulty becomes minimal. The unusual period of time which has elapsed between stages in some cases in this series may be explained by the duration of the osteomyelitis before this method of treatment was instituted, the degree of osteosclerosis about the fracture site at the time of primary operation, and the lack of experience necessary to determine adequately the proper method of dealing with this type of reconstruction.

The Second Stage: Application of Split-Thickness Skin Graft

The use of the Padgett dermatome enables the operator to obtain without difficulty grafts of predetermined thickness, and to provide sufficient skin to cover the largest saucerized areas. This graft, preferably .010 to .016 of an inch thick, is obtained from the most convenient source, and its rubberized epithelial surface is lightly dusted with sterile powder to prevent adherence to the dressing. The recipient area is prepared by curettage of the granulating surface, with removal of any tissue which is oedematous or avascular. The graft is then applied to the saucerized area, and is fitted into the depressed, irregular bone cavity by shaping the thin sheet of split skin into an irregular blunt cone. The graft margins are sutured to skin edges, and a pressure dressing of machinist's waste is meticulously placed from the bottom of the cavity outward, so that all recesses are completely and snugly filled, to ensure intimate contact between the graft and the recipient area. The entire extremity is wrapped with an elastic bandage, and immobilization is carried

out by means of a splint or cast. Chemotherapy, consisting of penicillin with or without sulfonamides, is administered for two or three days postoperatively. The initial dressings are routinely removed at the end of six days, and a plain vaseline-gauze dressing is applied. At this dressing, it is customarily found that from 80 to 95 per cent. of the skin graft has taken, and, not infrequently, the entire surface is completely covered with epithelium. Subsequently the wound is treated in the same manner as any skin graft, while proper attention is paid to immobilization of the underlying fracture. Physiotherapy is instituted for treatment of joints and soft tissues, as soon as the degree of healing permits.

When the grafted surface has become completely epithelialized, and the graft is relatively stable, further surgery is indicated for the obliteration of the bone cavity.

The Third Stage: Obliteration of the Bone Cavity with Autogenous Bone Chips

The principal factors in the success of this stage are:

1. Planning of suitable full-thickness covering for the defect;
2. Complete excision of the split-thickness covering from the depth of the saucerized area;
3. Procurement of a sufficient amount of bone chips to fill the cavity;
4. Covering of the chip-filled cavity with skin and subcutaneous tissue, in such a manner that tension is avoided.

In planning the final skin covering for the defect, it is frequently possible to undercut the margins of the skin adjacent to the cavity, so that viable full-thickness skin may be closed over the cavity without tension. It has been found advisable, when possible, to plan the closure so that the suture line does not overlie the cavity, as it has been found that the incision apparently heals better when not placed directly over the recently filled cavity. Therefore, it is frequently necessary to elevate a double-pedicle sliding flap in the region adjacent to the cavity, and to shift the flap to relocate the suture line. These flaps may usually be shifted without delay, and their viability will usually be satisfactory, if the ratio of length to width does not exceed three to one. In most cases one flap is adequate, but occasionally it is necessary to raise flaps on both sides of the cavity. Rarely, after the flaps have been elevated, their circulation may not seem adequate, so that it becomes necessary to "delay" the procedure for two or three weeks and return the flaps to their original beds. Occasionally, when an extensive loss of surface covering has occurred, it may be necessary to migrate skin and subcutaneous tissue by the pedicle method from more distant sources. It is imperative, therefore, that skin flaps actually be prepared and tested over the defect, before any effort is made to excise the initial graft or to apply the bone chips.

With satisfactory full-thickness covering of the defect assured, it is safe to proceed with the excision of the split-thickness lining of the saucerized area. The medullary canal of both fragments is reopened, and the bone surfaces are scarified throughout. Autogenous bone chips are then procured from any convenient source in quantities sufficient to fill the cavity (the wing of the ilium provides an excellent source). These chips are transferred to the prepared cavity, and the flap or flaps are shifted over the bone-filled cavity. A split-thickness graft, obtained from the thigh, is utilized to cover the denuded area representing the former location of the pedicle flap. Pressure dressings of machinist's waste are again carefully applied, and held with elastic bandages. Chemotherapy is continued postoperatively for a period of three to five days, and the suture line and skin-flap covering of the graft are inspected on the sixth day.

As soon as the sutures have been removed, the extremity is immobilized according to the degree of bony union which exists.

A brief synopsis of cases treated by this method, in a series of patients wounded in combat, is summarized in Table I.

FIG. 1-A

Photograph prior to final-stage operation, showing split-thickness graft lining cavity.

FIG. 2-A

Photograph prior to final-stage operation.

FIG. 1-B

Photograph two weeks after final operation.

FIG. 2-B

Photograph showing final result. Two months after operation.

FIG. 1-B

Photograph two weeks after final operation.

FIG. 2-B

Photograph showing final result. Two months after operation.

FIG. 1-C

Fig. 1-C: Roentgenogram of bone cavity after saucerization, prior to final-stage operation.

FIG. 1-D

Fig. 1-D: Roentgenogram following insertion of chips from ilium and plastic repair.

FIG. 2-C

Fig. 2-C: Roentgenogram showing structural weakness prior to final-stage operation.

FIG. 2-D

Fig. 2-D: Postoperative roentgenogram of chip-filled cavity in femur, showing solid union; clinically firm.

FIG. 3-A
Photograph prior to final-stage operation.

FIG. 3-B
End result, showing good skin coverage.

FIG. 4-A
Cavity lined with split-thickness skin.

FIG. 4-B
Appearance at first dressing following final-stage operation.

End result, showing good skin coverage.

Appearance at first dressing following final-stage operation.

FIG. 3-C

FIG. 3-D

Fig. 3-C: Roentgenogram showing skin-lined bone cavity (filled with barium sulfate to show the depth of the cavity).

Fig. 3-D: Roentgenogram showing cavity filled with bone chips from the ilium.

FIG. 4-C

FIG. 4-D

Fig. 4-C: Roentgenogram before reconstruction with bone chips.

Fig. 4-D: Roentgenogram after reconstruction with bone chips.

FIG. 5-A
Photograph showing fracture site prior to final-stage operation.

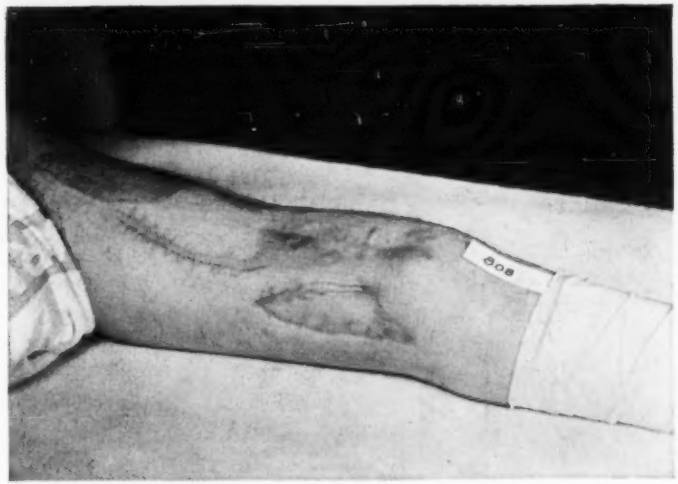

FIG. 5-B
Photograph showing result two months after final operation.

FIG. 5-C

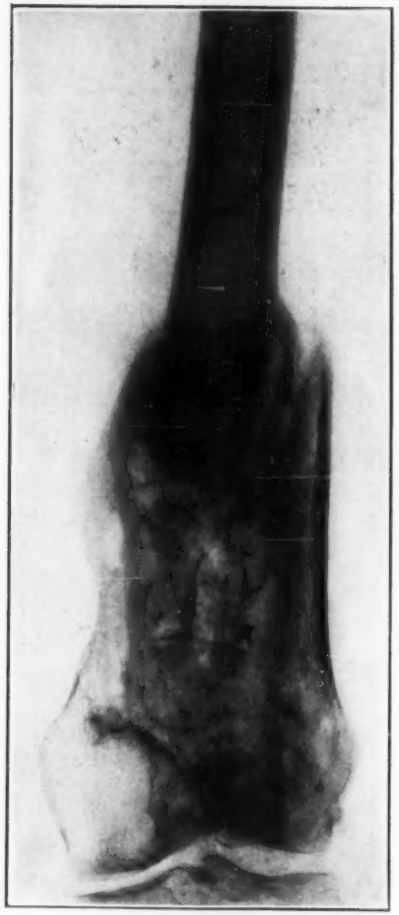

FIG. 5-D

Fig. 5-C: Roentgenogram showing depth of the cavity (filled with barium sulfate).
Fig. 5-D: Roentgenogram showing cavity filled with chips.

Photograph showing result two months after final operation.

FIG. 6-A

FIG. 6-B

Fig. 6-A: Roentgenogram showing proximity of cavity to knee joint.
Fig. 6-B: Roentgenogram showing preservation of joint following insertion of chips.

FIG. 7-A

FIG. 7-B

Fig. 7-A: Recent case, showing deep wound from shrapnel.
Fig. 7-B: Showing rapid healing after insertion of bone chips.

TABLE I

SUMMARY OF CASES

Case Number	Age	Involved Bone	Intervals			Obliteration of Bony Defects by Bone	Soft-Part Healing	Complications
			Injury to initial step	Sequestrectomy to S.T. graft	Graft to final operation			
			Months	*Days*	*Weeks*			
1.	23	Tibia	2	17	12	Complete	Complete	Hematoma (evacuated).
2.	28	Tibia	2	19	14	Complete	Complete	None
3.	25	Tibia	1.5	37	7	Complete	Complete	Hematoma (aspirated).
4.	29	Femur	5	44	9	Complete	Complete	None
5.	25	Tibia	1.5	11	8	Complete	Complete	None
6.	20	Tibia	4.5	14	15	Complete	Complete	None
7.	24	Tibia	1.5	36	12	Complete	Complete	None
8.	23	Tibia	6	14	8	Complete	Complete	None
9.	29	Tibia	5.5	29	10	Complete	Complete	None
10.	19	Femur	5	18	9	Complete	Complete	None
11.	25	Femur	4.5	19	8	Complete	Complete	None
12.	21	Tibia	6	12	6	Complete	Complete	None
13.	23	Femur	6.5	10	7	Complete	Complete	None
14.	27	Tibia	4	8	9	Incomplete	Incomplete	Suppuration present (bone chips viable).
15.	22	Tibia	3.5	7	5	Complete	Complete	None
16.	28	Tibia	3	8	8	Complete	Complete	None
17.	30	Tibia	2.5	9	7	Complete	Complete	None
18.	23	Femur	3	10	8	Incomplete	Incomplete	Draining sinus near operative site.
19.	25	Femur	4.5	7	8	Complete	Complete	None
20.	21	Tibia	2	8	5	Complete	Complete	None
21.	26	Tibia	3.5	9	7	Complete	Complete	None
22.	27	Tibia	3	10	6	Complete	Complete	None
23.	21	Tibia	2.5	7	9	Complete	Complete	None
Average	24	Tibia 17 Femur 6	3.5	16	8.5			

SUMMARY

A method of treatment has been described for the obliteration of large bone cavities, following traumatic osteomyelitis in compound fractures. This method consists of three stages: (1) adequate sequestrectomy; (2) application of split-skin graft; and (3) excision of the initial skin graft, application of bone chips, and transfer of a full-thickness skin graft.

Thus far, of the twenty-three cases reported, the wounds in all but two cases have entirely healed. Bone sepsis has been eradicated in all cases of the series; and in all, the defects have been eliminated. There has been no sequestration of any of the chips, and no roentgenographic evidence of osteomyelitis following the insertion of the bone chips. In the two cases in which healing is not complete, the bone defects have been eliminated, bony union is solid, but the soft-tissue healing is not sound, because of error in the skin-graft technique, resulting in inadequate blood supply. Careful planning of the full-thickness skin-grafting will ensure sound healing.

NOTE: Expressions of appreciation are due Mr. L. R. Johnson of Cleveland, Ohio, for his untiring effort in taking and producing the photographs.

TREATMENT OF BENIGN GIANT-CELL TUMOR IN THE LOWER THIRD OF THE FEMUR BY CURETTAGE AND "TELESCOPING" THE FRAGMENTS OF BONE *

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Included among the conservative surgical procedures for treating benign giant-cell tumors in the lower third of the femur are resection of the involved area, followed by bone-grafting, and curettage and chemical cauterization, with or without the filling of the cavity with bone chips.

Since about 40 per cent. of all giant-cell tumors of bone occur in young adults, treatment which permits removal of the growth, and yet retains mobility of the knee, is desirable. Often, the cortical shell about the tumor is so thin that fractures occur; or the cavity is so large that the healing process is exceedingly long.

In 1936 a patient came to us suffering from a giant-cell tumor of the femur, which had undergone rapid enlargement during a recently concluded pregnancy. Extensive destruction had spread to the joint surface of the condyles, and a pathological fracture had already occurred. It was an especially difficult case, because the patient had to return very soon to her home in the Venezuelan oil fields, where her husband was employed. Therefore, any cure which we might be able to effect had to be as certain as possible, and every effort had to be made to retain function of the leg and knee joint, because in the isolated district where the patient's home was located medical attention would be practically unobtainable.

For a time, it seemed to us that amputation would provide the only solution. However, in an attempt to prevent this, we performed our first "telescoping" operation. This met with such prompt and permanent success that we have since employed it in a series of five similar cases. The authors offer it as an excellent compromise between the extreme conservatism of grafting procedures and the radicalism of amputation, which has been resorted to in so many cases.

OPERATIVE PROCEDURE

The operation is performed with a tourniquet. The involved area of bone in the distal end of the femur is exposed, and a window is cut in the thinnest part of the cortex. Through this opening, the tumor is removed by curettage, care being taken not to break through the articular cartilage into the knee joint, or through the posterior cortex. All soft tissues are carefully protected by sponges, and the cavity is cauterized with pure phenol, and washed out with alcohol. The remaining cortex is then carefully osteotomized, and the distal fragment is forced up around the end of the shaft of the bone, thus telescoping the fragments and filling the cavity with the end of the proximal fragment. Chromic catgut sutures are used to close the cortex and the periosteum as tightly as possible, to reapproximate the muscles, and to close the fascia tightly. The skin is closed in the usual manner. No packs or drains are used. A plaster hip spica is applied with the knee partially flexed. The tourniquet is removed after the cast has been applied to the leg.

The results in the cases in which this method was employed have been gratifying. There have been no instances of unusual bleeding, and no infections. Function of the knee after healing is good, and full weight-bearing on the leg is obtained. There is shortening of the leg by one to three inches (2.5 to 7.5 centimeters), depending upon the size of the cavity, but this is easily corrected by a lift on the shoe of the affected side, or even by

* Prepared for presentation at the Meeting of The American Orthopaedic Association, May 1945, which was cancelled in compliance with the request of the Office of Defense Transportation.

FIG. 1-A

Case 1. Preoperative anteroposterior and lateral roentgenograms of the left knee, showing tumor involving the distal end of the left femur, but with the articular cartilages intact.

FIG. 1-B

Roentgenograms of the left knee two months after operation, showing resection of the tumor, telescoping of the fragments, and the articular cartilages still intact.

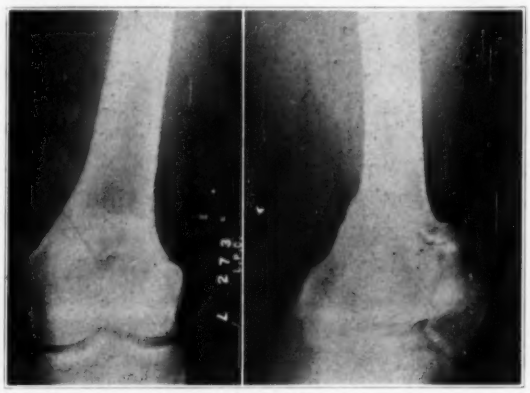

FIG. 1-C

Anteroposterior and lateral roentgenograms three years and nine months after operation, showing left knee with good healing of fragments and no evidences of recurrence of the tumor.

operative shortening of the opposite leg. The healing time is somewhat longer than that for a comminuted supracondylar fracture of the femur. The position of the bone fragments is shown in the illustrations of the cases described.

FIG. 2-A

Case 3. Preoperative anteroposterior roentgenogram of the right knee, showing extensive multilocular tumor involving the distal end of the femur, but with the articular cartilages intact.

CASE 1. S. M., a white woman, twenty-three years old, had had pain and swelling in the left knee for seven months, and had lost ten pounds in weight. Physical examination revealed atrophy of the thigh and calf muscles of the left leg, and a flexion deformity of the left knee of about 20 degrees. The patient could fully extend the knee, but with pain. There was a fusiform swelling involving the entire circumference of the shaft of the left femur just above the distal epiphysis. Roentgenograms showed a large mass, characteristic of a giant-cell tumor, involving the distal end of the left femur, but not affecting the knee joint. On July 8, 1936, the tumor was removed by curettage and carbolization; the fragments were telescoped; and the wound was closed without drains. Upon microscopic examination, the tissue removed at operation was found to be a benign giant-cell tumor. Serial roentgenograms revealed good healing, and four years after the operation the patient was living an active life in the tropics, with full function of the knee and leg. The final shortening was three-fourths of an inch.

CASE 2. I. J., a white woman, fifty-eight years old, had noticed pain and a progressive swelling of the right knee. Examination revealed a diffuse swelling of the right knee, and tenderness and limitation of motion. Roentgenograms revealed a mass, characteristic of a giant-cell tumor, involving the distal portion of the right femur, but the articular cartilages of the knee were intact. On May 17, 1937, the

FIG. 2-B

Lateral and anteroposterior roentgenograms of the right knee two months after operation, showing resection of the tumor, telescoping of the fragments, and the articular cartilages still intact.

FIG. 2-C

Roentgenograms of the right knee three years after operation, showing good healing of the fragments and no evidences of recurrence of the tumor.

tumor was excised by curettage, followed by cauterization of the cavity with pure phenol. The fragments were telescoped, and the wound was closed tightly without drains. Upon microscopic examination the excised tissue was found to be a benign giant-cell tumor. The postoperative course was uneventful, and on August 24, 1937, all immobilization was removed. The femur was clinically solid, and roentgenograms showed firm bony union. The final shortening was one inch (2.5 centimeters).

CASE 3. R. J. M., a white woman, twenty-two years old, fell on her right knee in January 1939, and had had persistent pain in the knee thereafter. In February 1940, she tripped again, and felt something snap in her right knee. Roentgenograms revealed in the distal end of the right femur a mass with the characteristics of a giant-cell tumor. The articular cartilages of the knee joint were intact. On August 2, 1940, the tumor was excised by curettage, followed by cauterization of the cavity with pure phenol and telescoping of the fragments. Microscopic examination showed the excised tissue to be a benign giant-cell tumor. The wound was closed without drains. After nine weeks the femur was clinically solid, and roentgenograms showed good bony union. Two years later the patient was bearing weight on the leg freely; there was satisfactory motion in the knee joint; and, upon roentgenographic examination, no evidence of reactivation of the tumor was found. The final shortening was three inches (7.5 centimeters).

CASE 4. V. C. W., a colored girl, twenty-eight years old, had had pain in the right knee for eight months following a fall on the knee on July 4, 1943. Physical examination revealed a generalized swell-

FIG. 3-A

FIG. 3-B

Case 5. Preoperative roentgenograms, showing extensive destruction of cortex and medulla by tumor.

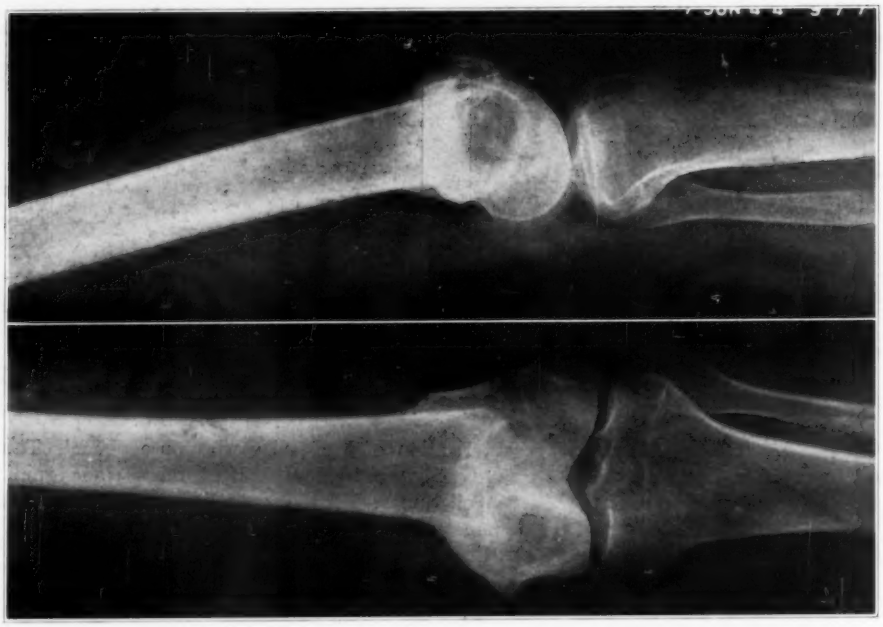

Fig. 3-E
Roentgenograms, one year after operation, show healing with no sign of recurrence.

Fig. 3-D
Immediate effect of telescoping.

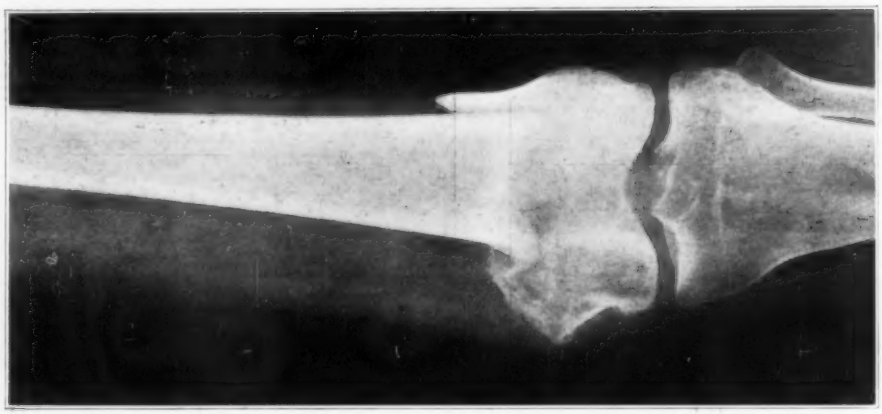

Fig. 3-C
Postoperative roentgenograms, showing

ing about the right knee, most marked in the supracondylar area. Motion of the knee was limited to the range of 170 to 85 degrees. Roentgenograms showed a mass with the characteristic appearance of a giant-cell tumor occupying the distal end of the right femur, but not invading the knee joint. On March 20, 1944, the tumor was removed by curettage, followed by cauterization of the cavity with pure phenol. The fragments were telescoped, and the wound was closed without drains. The postoperative course was uneventful. Microscopic examination showed the excised tissue to be a benign giant-cell tumor. When the cast was changed twenty-four days after the operation, the wound was clean and well healed; and after nine weeks, union of the fragments was progressing satisfactorily. The final shortening was one and one-half inches (3.75 centimeters).

CASE 5. M. D., a white girl, twenty-five years old, complained of pain in the left knee, and of the formation of a bony mass of twelve months' duration. A marked increase in symptoms had occurred during the past five months. The examination showed the knee to be swollen to one and a half times the normal size. There was a firm mass, extending from two inches (five centimeters) above the joint line. There was muscle atrophy, and motion was restricted and had been painful since the patient had bumped the knee one month previously. There was no local temperature elevation. The roentgenograms revealed a large central tumor in the lower end of the femur which had broken through the cortex.

Before the operation, x-ray therapy was given. The operation was performed on June 3, 1943. When the tumor mass was excised, it was found to have eroded part of the anterior cortex, the medial, and the posterior cortex. Through the posterior cortex it extended into the popliteal space. Following osteotomy, the shaft was telescoped into the condylar dead space, filling it well. Microscopic section showed a benign giant-cell tumor. The wound was closed tightly, and a cast was applied. Healing occurred *per primam*. The cast was removed on September 28, 1943, and the femur was healing well. The patient was discharged on crutches, and graduated weight-bearing was begun. At present the patient reports excellent function, and the final shortening is not enough to require shoe alteration.

SUMMARY

There has been described an operation for the conservative surgical treatment of benign giant-cell tumors in the distal end of the femur, in cases in which the articular cartilages of the knee joint are intact. This method permits removal of the tumor, and yet retains mobility of the knee joint and the full weight-bearing function of the leg. The procedure consists of obliterating the cavity by telescoping the fragments of bone, after removal of the tumor by curettage and chemical cauterization. To date the patients (all women) have accepted the shortening incurred, and have declined our offers to equalize length by operative shortening of the normal limb.

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LOCAL CHEMOTHERAPY WITH PRIMARY CLOSURE OF SEPTIC WOUNDS BY MEANS OF DRAINAGE AND IRRIGATION CANNULAE

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INTRODUCTION

The fundamental principle in the treatment of deep sepsis is the creation of a path or preferably an avenue of escape for the accumulated products of infection. "Packing the wound open" is the method generally used to accomplish this purpose, but it has many drawbacks. Making a wound close from the bottom means a prolonged period of healing, during which time there is bound to be considerable loss of serum from the granulating surfaces; this fact alone is a serious objection to drainage by packing the wound open. Relatively frequent dressings, painful to the patient, and time-consuming for the surgeon, are another objection to the method. Partial primary closure of the wound is the logical answer to this problem.

HISTORICAL BACKGROUND

Development of Drainage and Irrigation Cannulae

In 1934 the first "drainage and irrigation cannulae" (Fig. 1) were made for the Osteomyelitis Service of the Massachusetts General Hospital. These were straight glass cannulae, each with a flange at one end to prevent it from slipping out of the wound. After incision and drainage of an osteomyelitic area, two of these cannulae were inserted, and the wound was closed tightly around them. Rubber tubes were connected to the cannulae,—one leading to a bottle of irrigating fluid at the head of the bed, the other to a waste bottle on the floor. At regular intervals, irrigation fluid was allowed to flow through the wound until it came out clear; the rubber tube from the outlet cannula was then clamped off, allowing the irrigation fluid to accumulate in the wound before the rubber tube from the supply bottle was clamped off. Dakin's solution was the agent used both for its cleansing and for its bacteriostatic effect.

Several members of the Osteomyelitis Service did not look with favor upon this method of treatment, and the orthopaedic surgeon responsible for the treatment did not feel any too confident; consequently, the cases treated in this manner were few and far between, and progress was proportionally slow.

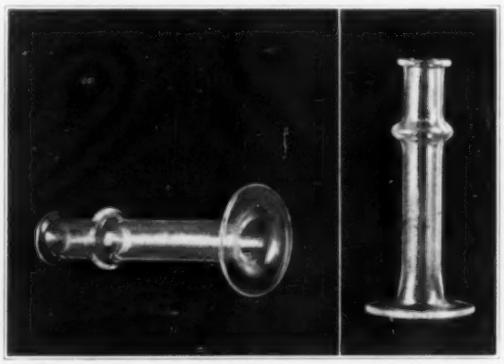

FIG. 1

Original glass drainage and irrigation cannulae (February 1934).

FIG. 2

Modified glass cannulae: elliptical, neck bent, strut added (April 1935).

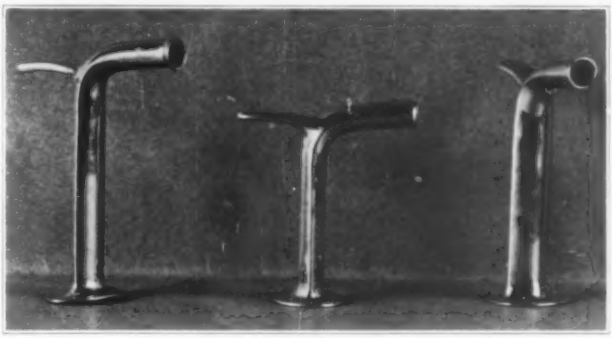

FIG. 3
Vitallium cannulae, present models (1938).

It was soon found that the round glass cannulae allowed leakage, and also caused pressure necrosis of the skin edges. Furthermore, they teetered sideway, and were apt to slip down against the bony floor of the cavity. These difficulties were gradually overcome; the cannula was made elliptical to avoid leakage and pressure on soft parts (Fig. 2), the neck of the cannula was bent at a right angle and a strut was added. These changes permitted stabilization of the cannula by providing space in which to pack gauze between the skin and the neck and strut (Fig. 2). Glass was not ideal because of the possibility of breakage; so, in 1938, the first vitallium cannulae were made (Fig. 3). Only minor changes in shape and caliber have been made since that time.

Irrigation Fluids and Chemotherapeutic Agents

Dakin's solution has been used extensively from the very first, and even now it is often substituted temporarily for other chemotherapeutic agents.

Silver-pectinate solution has been used in a limited number of cases as a local chemotherapeutic agent, but not as an irrigation fluid.

Penicillin has been used for the last year. The system of two drainage and irrigation cannulae has been found to be a very practical way of introducing the penicillin locally (Figs. 4 and 5).

TECHNIQUE

After primary closure of the wound around the cannulae, gauze sponges are packed between the skin and the neck, as well as between the skin and the flange or strut (Figs. 6 and 7). This packing stabilizes the cannulae and prevents them from teetering; it also keeps the deep portions of the cannulae away from the floor of the septic area. Additional dressing is applied, and held in place by an elastic bandage. By introducing a certain number of cubic centimeters of air through a syringe, a corresponding amount of fluid is delivered from the supply bottle into the wound through the inlet cannula. The outlet cannula is left open until clear fluid appears; then it is clamped off.

When penicillin is used as the local chemotherapeutic agent, the amount decided upon is delivered into the wound by the above technique every four hours. The strength of the solution up to the present has been 250 units per cubic centimeter. The period of local administration of penicillin has varied from a minimum of two weeks to a maximum of four weeks. It is decided upon on the basis of the extent and the duration of the sepsis, preoperatively, as well as the clinical course postoperatively. If at any time a change in the local chemotherapeutic agent is indicated, the system is kept intact except for the supply bottle and its contents. Indications for such a change are: secondary infection, such as *Bacillus coli* or other penicillin-resistant organisms, or interference with the flow of penicillin through the septic area. Dakin's solution has been the only chemotherapeutic agent used as a temporary substitute for penicillin. Dressings are infrequent,—the dressing applied at the time of operation is frequently left undisturbed for a week or ten days; local discomfort from a sticky, bloody dressing may demand a change as early as three or four days after operation, but, after this initial change, there may be no indication for dressings until the cannulae are removed.

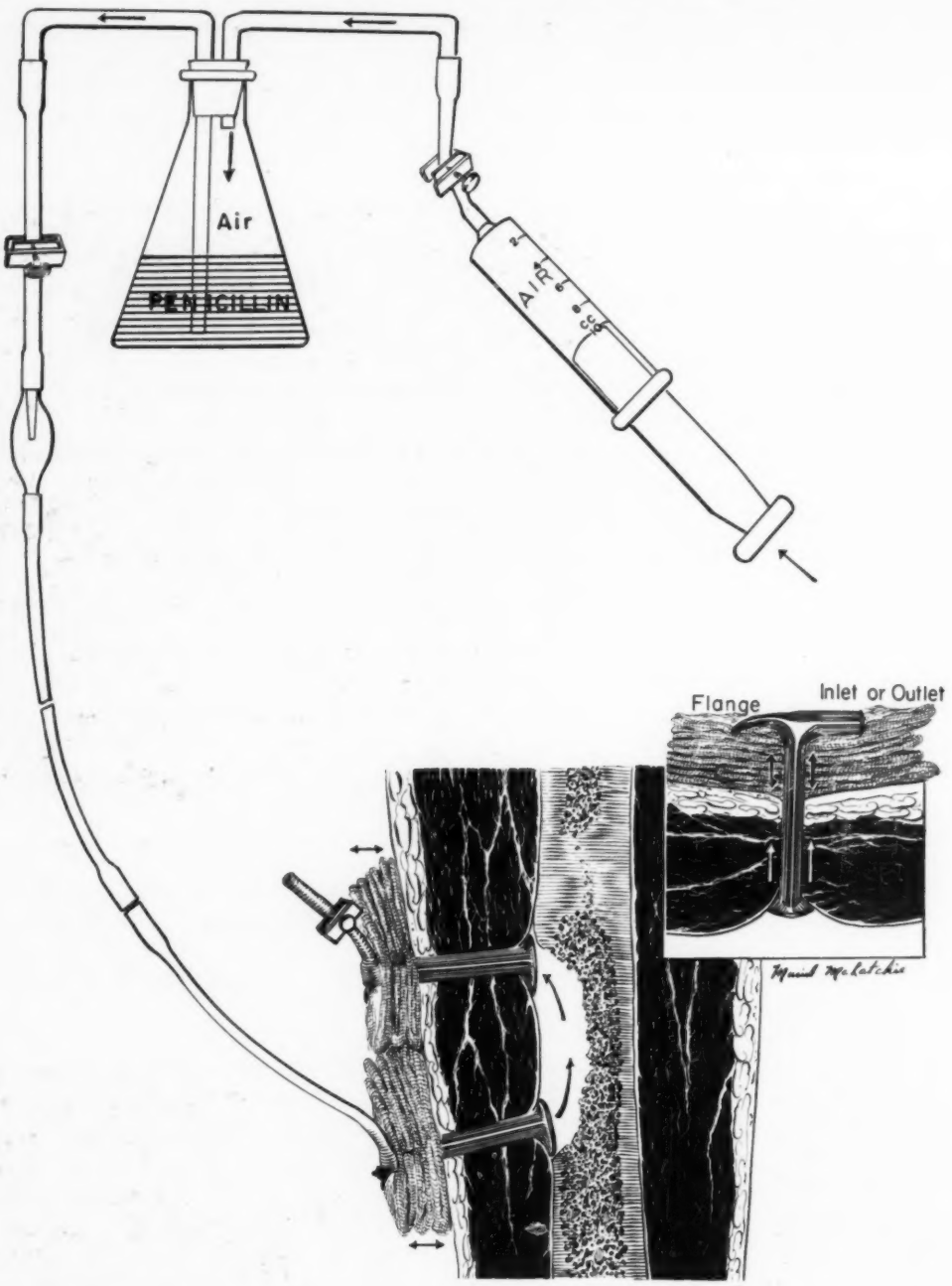

FIG. 4

Diagrammatic representation of the use of cannulae in connection with a closed system for the local administration of penicillin.*

Removal of Cannulae

During the developmental stage, the cannulae were removed under local anaesthesia at the end of two to four weeks, without any attempt being made to close the soft-tissue defects created by them. Consequently, dressings were necessary for varying periods of time, but they were minor, not time-consuming and not painful. Since the advent of penicillin, the technique has changed only slightly: The cannulae are still being removed

* This closed system of local administration, as now used, originated with two Surgical Residents, Grant Rodkey, M.D., and Richard Webster, M.D.

at the end of two to four weeks, usually under pentothal anaesthesia, but the soft-tissue defects are closed, leaving only a small rubber catheter in place for the administration of penicillin for a few more days. This use of the catheter is a sign of lack of faith in nature's ability to combat residual infection successfully; cultures taken at the time of the removal of the cannulae invariably show bacterial growth.

Systemic Chemotherapy

Bacteraemia and septicaemia are ever-present threats accompanying local infection. Systemic chemotherapy has made miraculous progress during the last few years, and it would be poor judgment indeed to confine ourselves to the use of local chemotherapy. Systemic penicillin has been administered for a minimum of twenty-four hours before operation, throughout the period of local chemotherapy, and for a few days to a week following the removal of the cannulae; 100,000 units per twenty-four hours has been the usual dosage.

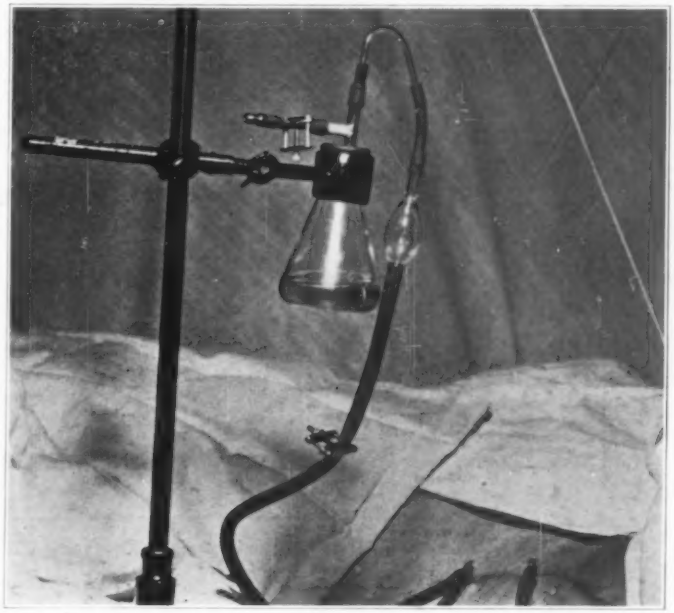

FIG. 5
Apparatus in use in a case of hip-joint sepsis.

Variations in Technique

The number of cannulae at our disposal has been and still is very limited. Consequently, there have been occasions when no cannulae were available; at such times rubber catheters have been used in their place. The technique of wound closure and local instillation of penicillin has been the same as that employed with the cannulae. Rubber catheters clog more easily, and may cause local reaction.

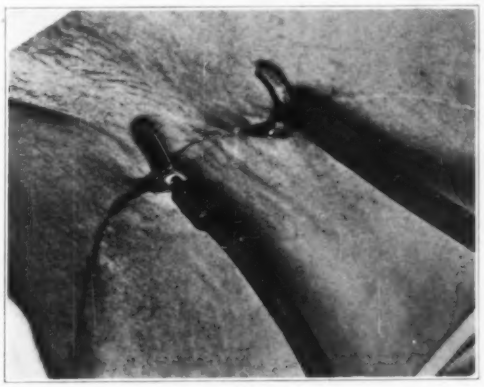

FIG. 6
Close-up view of cannulae in place twelve days after insertion. Very minor local reaction.

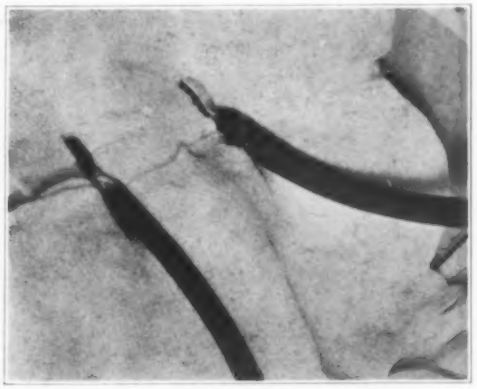

FIG. 7
Same case as Fig. 6. Packing in place.

CASE REPORTS

This is a preliminary report of a method of local treatment of sepsis. Our experience with it has been so favorable that we feel justified in submitting it for trial. It has not

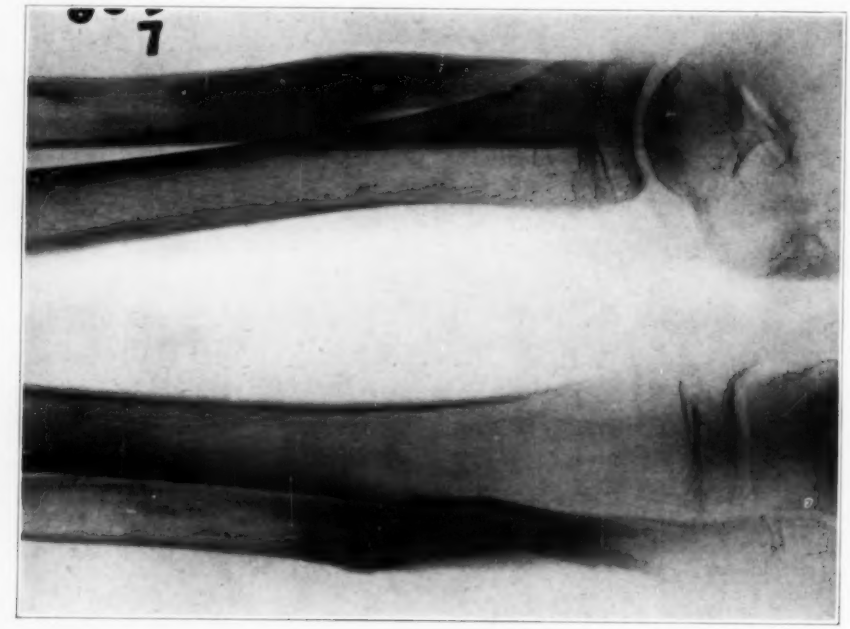

FIG. 8-C

Roentgenogram eight weeks after original operation,—six weeks after removal of cannulae.

FIG. 8-B

Roentgenogram after saucerization and insertion of glass cannulae.

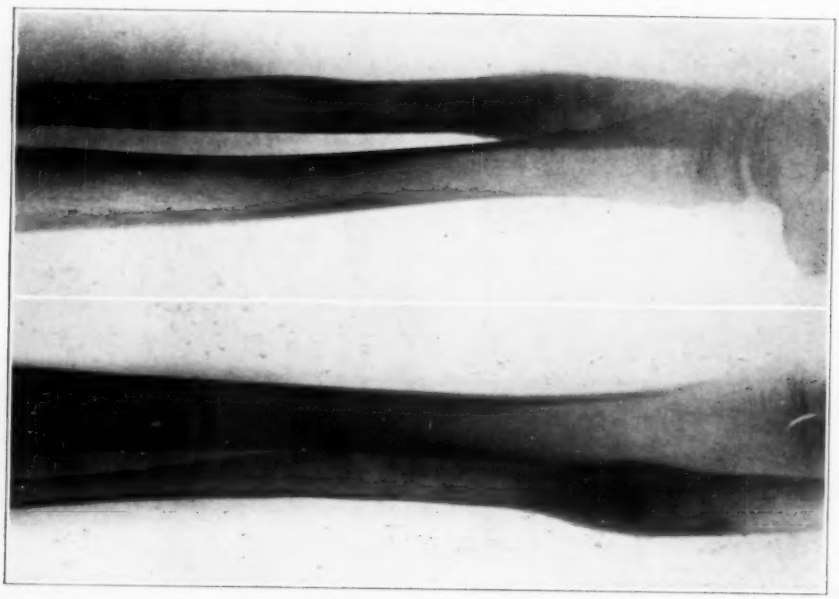

FIG. 8-A

Case 1. Osteomyelitis of the left fibula before operation.

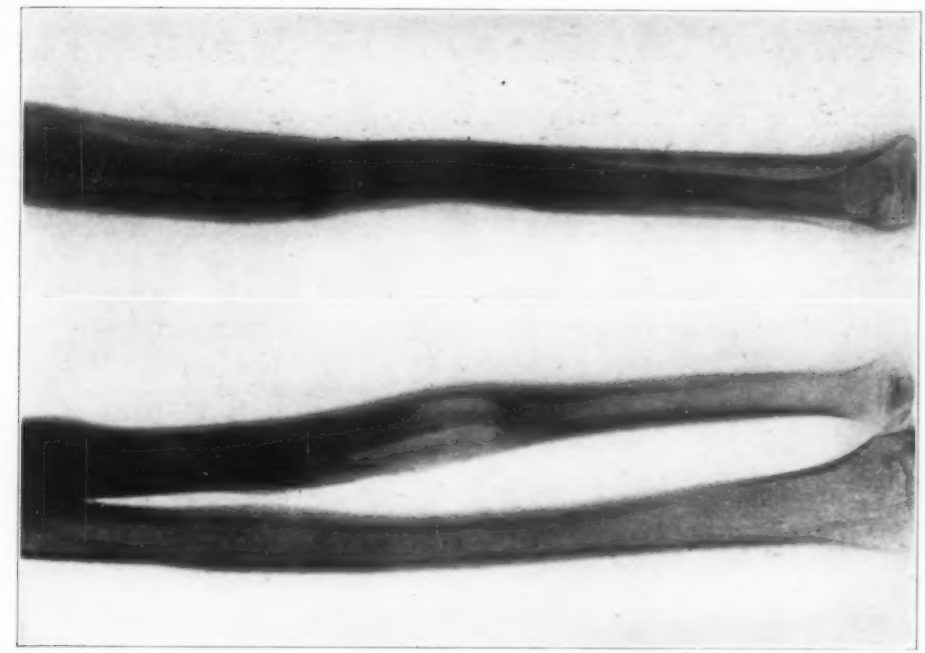

FIG. 9-C

After removal of cannulae. Wound healed in five weeks. No local recurrence.

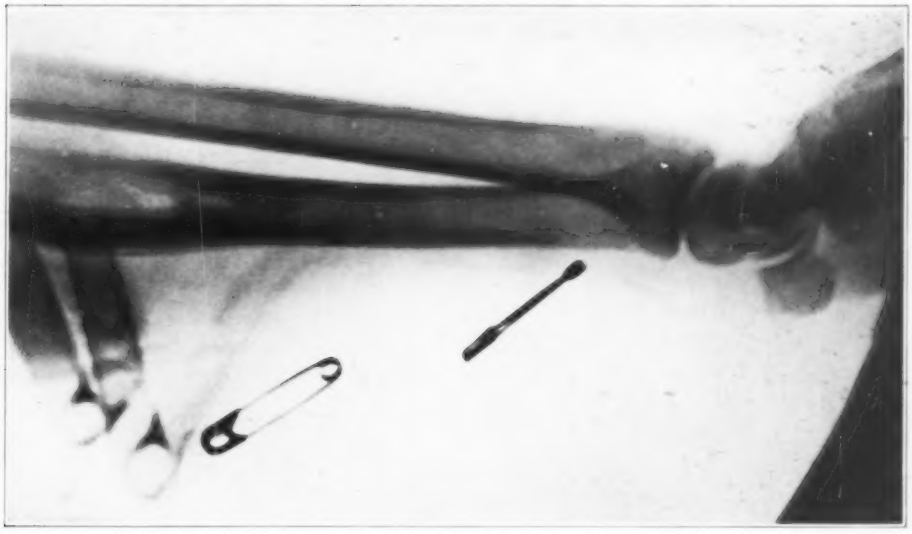

FIG. 9-B

After operation,—saucerization, insertion of glass cannulae, and closure of wound.

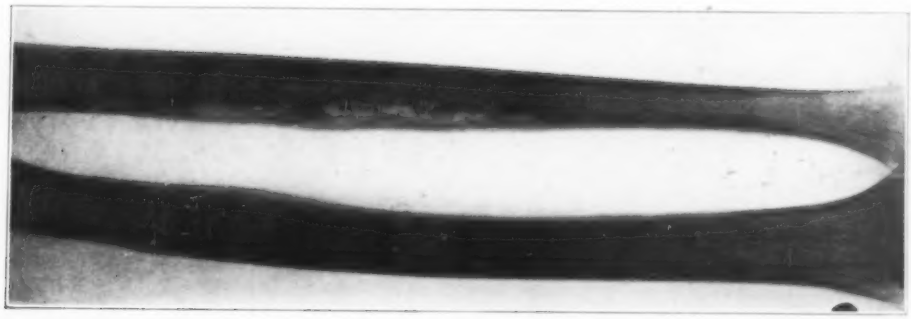

FIG. 9-A

Case 2. Osteomyelitis of right ulna before operation. March 1934.

been used in combination with systemic chemotherapy for a long enough period to allow an end-result study.

Three of the early cases are reported. They were selected not only because they are favorable, but also because they are typical. The roentgenograms are reproduced from lantern slides, since the films are no longer available.

One case, treated by systemic and local penicillin, is reported as an illustration of the present method.

CASE 1. A boy of thirteen had recurring osteomyelitis of the left fibula of two and a half years' duration (Fig. 8-A). At operation saucerization was performed, and two glass cannulae were inserted (Fig. 8-B). The cannulae were removed under local anaesthesia twelve days later, without repair of the

FIG. 10-A

Case 3. Old septic hip with lipiodol injection of sinus.

FIG. 10-B

Old septic hip after vitallium-mold arthroplasty and insertion of two vitallium cannulae.

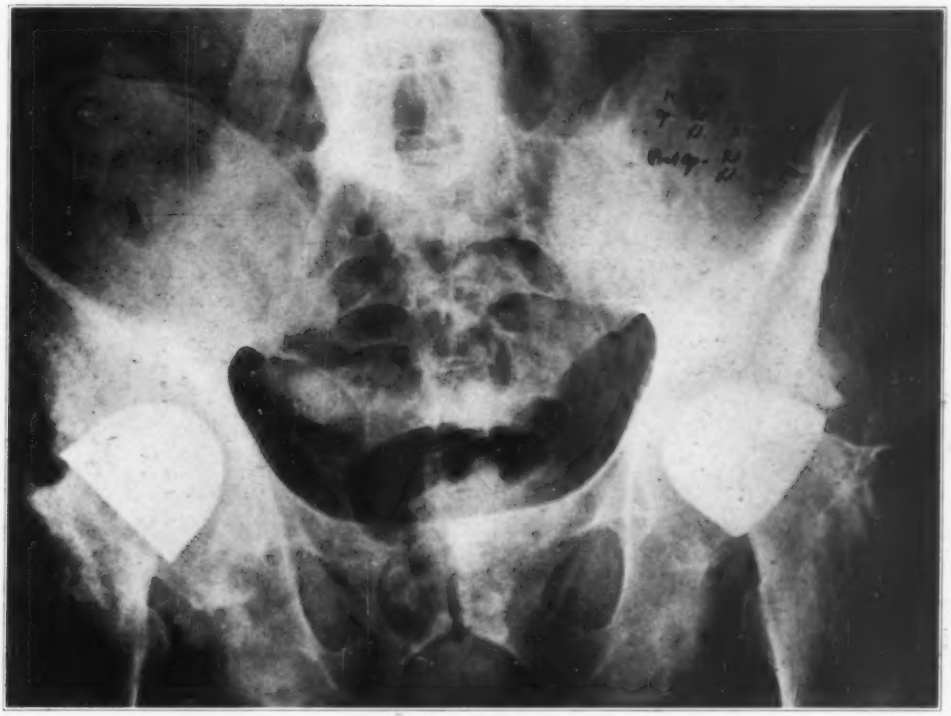

FIG. 10-C
Seven months after removal of cannulae. Wound healed. No recurrence of sepsis.

skin defects. The wound healed completely in one month. Roentgenograms, made eight weeks after the operation, showed satisfactory bone repair, with no sequestra, and no areas suggestive of persistent infection (Fig. 8-C).

This was one of the cases treated during 1934, the first year the cannulae were used. Almost eleven years have elapsed without any recurrences.

CASE 2. A student of twenty-four had recurring symptoms referable to his right ulna. Roentgenograms (Fig. 9-A) showed changes characteristic of osteomyelitis. Operation in 1934 consisted in sequestrectomy, saucerization, and the insertion of glass cannulae (Fig. 9-B). The wound healed completely in five weeks (Fig. 9-C). There was no local recurrence, but several secondary foci developed during the nine years following this initial focus.

CASE 3. A man, thirty-eight years old, had rheumatoid arthritis, with a rigid spine, and fibrous ankylosis of both hips. In 1934 he had had a fascia lata arthroplasty of the left hip, with postoperative sepsis, which had persisted for five years (Fig. 10-A).

In December 1938 a vitallium-mold arthroplasty was performed on the right hip. Two months later, in February 1939, a vitallium-mold arthroplasty was performed on the left hip, and free pus was encountered in the iliac fossa. Two vitallium cannulae were inserted, and the wound was closed around them (Fig. 10-B). One month later the cannulae were removed (Fig. 10-C).

At the time of the patient's discharge from the Hospital, the wound was healed, and there has been no recurrence of sepsis up to the present, a period of six years. The patient has fair function of both hips, and is working at a job requiring standing from four to six hours a day.

CASE 4. A student of nineteen had multiple foci of osteomyelitis, occurring over a period of seven years. In July 1944, acute symptoms from a new focus, in the mid-shaft of the right femur, developed (Fig. 11-A). Operation included saucerization, and insertion of two vitallium cannulae, with wound closure (Fig. 11-B). Free pus was encountered in the medullary canal. The postoperative course was smooth. The patient was particularly appreciative of the absence of painful dressings, because of his previous experience with them.

Systemic penicillin, 100,000 units in twenty-four hours, was administered for ten days after operation, and for a week after the removal of the cannulae. Local penicillin was injected every four hours: ten cubic centimeters, 250 units per cubic centimeter. This was continued up to the time of the removal of the cannulae.

FIG. 11-A

Case 4. Osteomyelitis in mid-shaft, right femur. Preoperative roentgenograms.

FIG. 11-B

Postoperative roentgenograms, showing vitallium cannulae in place. Note how the dressing prevents the cannulae from resting on the floor of the saucerized area.

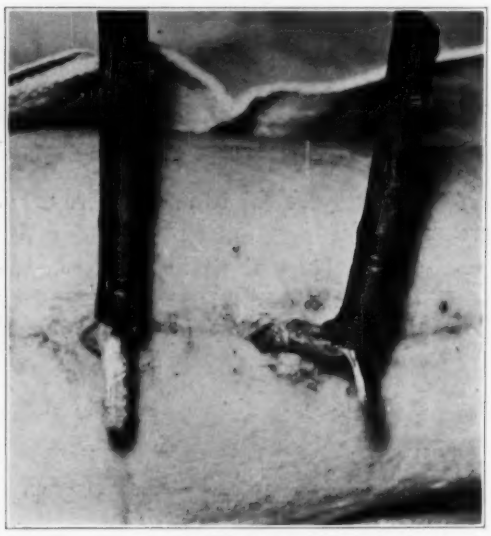

FIG. 11-C

Photograph of wound twenty-six days after insertion of the cannulae, just before their removal.

FIG. 11-D

Roentgenograms, six weeks after the original operation. Satisfactory progress of bone repair. Wound entirely healed.

The cannulae were removed on the twenty-sixth postoperative day (Fig. 11-C) under pentothal anaesthesia, and the defects were closed. A small rubber catheter was left in place, and penicillin was continued locally for ten more days.

The wound was entirely healed six weeks after the original operation. Roentgenograms at that time showed satisfactory progress of bone repair (Fig. 11-D).

Only ten months have elapsed since operation, but so far there has been no local recurrence of sepsis.

DISCUSSION

Favorable Aspects

Looking back upon eleven years of experience with local chemotherapy, administered through a closed system of cannulae, several favorable aspects stand out. The almost

complete primary closure reduces to a minimum the loss of serum from the granulating surfaces. This is important because the loss of serum protein can be considerable, as was demonstrated in one case treated by the method of "packing the wound open". The determined loss of serum protein for one period of twenty-four hours amounted to 36.9 grams; the average daily loss over a period of a week was 11.9 grams. True, this was not an average routine case, but it serves to emphasize the importance of reducing granulating surfaces to a minimum.

The infrequency of dressings appeals to the patient and to the surgeon. Septic dressings are painful, no matter how gently they are done; and they are bound to be time-consuming.

The time for complete healing of the wound is materially shortened; and the scar is linear and level, instead of broad and puckered.

The postoperative clinical course in the majority of cases treated by this method has been smooth: the temperature chart levels off quickly; the patients are happy and look well.

Unfavorable Aspects

This is not a perfected method with 100 per cent. cures. There have been cases with local recurrence of sepsis, but these have been relatively few.

No matter how carefully the cannulae are sutured in place and stabilized by proper packing, local reaction from pressure and slight motion is apt to occur. Such reaction is very slight and easily excised at the time of the removal of the cannulae.

The drainage and irrigation system is not immune to clogging. A change in fluid and flushing the wound usually eliminate obstructions without much difficulty.

Penicillin

With the great advances that have been made in chemotherapy in recent years, particularly since the advent of penicillin, a wider application of this method of treatment is possible. So far our experience has been limited to osteomyelitis of the extremities and bony pelvis. As further knowledge is gained regarding the effectiveness of penicillin and other chemotherapeutic agents, it becomes less and less hazardous to eliminate, partially or completely, soft-tissue defects in the presence of potential or even active sepsis. Topical application of the chemotherapeutic agents seems an important factor for success, and the cannulae are an efficient means of administering such treatment.

CONGENITAL ABSENCE OF THE RADIUS

A Method of Surgical Correction

BY D. E. STARR, M.D., VANCOUVER, BRITISH COLUMBIA, CANADA

Congenital absence of part or all of the radius has been reported by many, and methods of dealing with the deformity have been described by well-known authors.

In 1905, Antonelli reported 114 cases, and declared at that time that the deformity was more often single than double, and that it occurred more often as the result of partial absence of the radius, usually the distal end, than as the result of complete absence. Kümmel described the total absence of the radius in detail.

HISTORICAL BACKGROUND

Previously reported techniques are numerous. Sayre preceded his surgical correction by adhesive skin traction, in an attempt to overcome the radial deviation of the hand in relation to the lower end of the ulna. He then inserted the distal end of the radius into the carpus, from which some of the bones were removed. According to Kermisson and Langet, muscles on the radial side of the hand are usually missing. McCurdy, in his procedure, tenotomized the short tendons on the radial side, then severed the ulna at a point where the free end of the upper fragment could be brought into contact with the carpal lunate, which was curetted and fixed to the graft with silkworm gut. Bardenheuer split the ulna, and then allowed the carpus to fit into the bifurcated portion, fixing the bifurcation to the carpus with two ivory bone pegs. Tubby modified this procedure by using silkworm-gut fixation, instead of the ivory bone pegs. A kangaroo tendon was used by Rosswell Park for the same purpose. Ryerson described a technique in which a graft was removed from the ulna, and used as a radial shaft with fixation to the carpal region. No adequate fixation of the upper end of the graft was attempted. Albee used a tibial graft which he strutted from the ulna into the carpal bones. Steindler tenotomized the contracted radial tendons, and then did an osteotomy at the maximum bowing of the ulna. A bed was then prepared in the carpus, and the epiphysis was removed from the lower end of the ulna. The ulna was then pointed and inserted into the cleft in the carpal bones midway into the metacarpal region, and fixed with chromic catgut through drill holes. Campbell suggested a similar technique to Steindler's, but stated that the operative treatment should not be done before the patient has reached two years of age.

Treatment by manipulation and plaster fixation has also been attempted. Hassel described a simple osteotomy of the ulna. Romans described a cuneiform osteotomy in which the ulna was sutured to the carpus.

As far as one can gather, there appears to be no utilization of skeletal traction in preliminary correction of the deformity. Transplantation of the fibula to the forearm has been done to replace the previously resected radius, but not for congenital absence. Campbell described the insertion of the lower end of the radius for resected tumor masses involving the lower radius. The technique of removal and replacement has been described by Schauffler, where involvement of the humerus at the upper end was encountered.

METHOD

The segmental defect as seen and characterized by the absence of the radius is frequently associated with other congenital deformities of the same limb. It is extremely frequent to find absence of the first metacarpal, with or without absence of the thumb, and of the radial component of the carpal bones. Corresponding soft parts may be absent.

In attempting this new procedure, an effort was made to correct soft-tissue deformity before attempting bony correction, and to preserve the growing function of the remaining

ulna, which is already grossly shortened. It provides a means of allowing some freedom of the carpal bones, and, if possible, wrist motion. It was also possible to maintain moderate rotary motion of the forearm, where any portion of the upper end of the radius remained.

The metacarpal heads, therefore, were transfixed with a Kirschner wire, as was the olecranon, and Dunlop traction was applied to distract the forearm, at the same time directing the hand to the ulnar side (Fig. 2-C). Traction for six weeks stretched the soft tissues distal to the lower end of the radius. Traction also brought the remaining carpal bones into a position relatively distal to the lower end of the ulna.

An oblique osteotomy was then performed in the ulna, and the traction was maintained until union had occurred at the site of the osteotomy. Unfortunately, in the first instance, the osteotomy was too distal, and only part of the bowing of the ulna was corrected.

FIG. 1-A

Infant showing bilateral congenital absence of radius. Note bilateral absence of first metacarpal bone, and absence of thumb on the left.

FIG. 1-B

Maternal grandmother, showing absence of right thumb and presence of thumb with three phalanges on the left.

When thorough union had occurred, the Kirschner wires were removed, and the forearm was placed in plaster.

A third stage was then performed. The upper end of the fibula was removed extraperiosteally, and was transplanted to the forearm. Special care was taken to dissect the upper end of the fibular transplant in such a manner that the epiphyseal periosteum was not disturbed. The soft-tissue mass distal to the radius was removed, and this in part made room for the transplant. No difficulty was encountered in inserting the graft between the flexor and extensor tendons, although all the normal structures were not present, nor in maintaining the upper articular surface of the fibula in contact with the remaining carpal bones.

CASE REPORTS

The author has seen congenital absence of the radius in its various aspects in three cases, involving four limbs. Most interesting was a bilateral case with complete absence of the radius, the thumb, and the first metacarpal bones. Correction was not attempted because of the patient's age (Fig. 1-A). The maternal grandmother showed an absence of the first metacarpal and thumb on the right hand; while on the left, the thumb had three phalanges (Fig. 1-B).

FIG. 2-A
Case 2. Photograph of arm before correction.

FIG. 2-B

Fig. 2-B: Roentgenogram of arm before correction.

Fig. 2-C: Photograph, showing arm in skeletal traction.

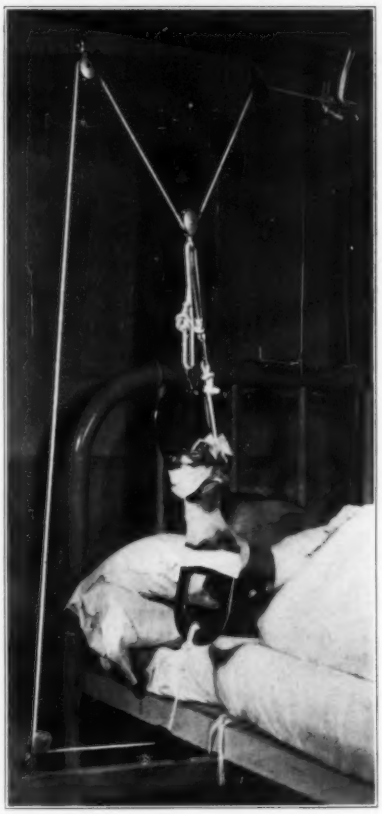

FIG. 2-C

The other two patients showed partial or complete absence of the radius. Both of these patients showed absence of some of the carpal bones, as well as the first metacarpal; one with a non-articulated thumb composed of two digits, the other without any evidence of a thumb.

This series comprises the usual variations found in this deformity, which is disabling and very unsightly. The forearm is short, the ulna is always bowed, and the hand is in extreme valgus. There is usually no wrist articulation, since the ulna is dislocated distal to the carpus. The absence of the thumb is also incapacitating.

CASE 2. This child was first seen at the age of ten years (Fig. 2-A). She was small of stature, but apart from the right forearm, was normally developed. There was no history of congenital deformity in the family. The method described was first carried out on this patient. There was not a complete absence of the radius. The lower end was atrophied, and the radius terminated in the lower third of the forearm in an irregular, pointed mass (Fig. 2-B). The space taken between the carpal bones, chiefly the ulnar components, and the distal end of the radius, was filled with a soft cartilaginous mass. The radius was markedly short and atrophied in comparison with the ulna. The ulna, definitely bowed, was grossly shortened in comparison with the normal arm, and did not articulate with the carpal bones.

The usual procedures did not seem applicable in this case, so it was decided to use what remained of the radius and to construct a lower radial graft, which would give a more permanent and more flexible correction. The free end of the transplant was tapered to dovetail with the freshened surface of the lower end of the radius.

The hand, forearm, and arm were then placed in plaster and maintained in fixation for ten weeks.

FIG. 2-D

Roentgenograms one and a half years after fibular transplant. Note patent epiphysis in transplant.

FIG. 2-E

Photograph one and a half years after correction.

The forearm exhibited the usual radial contractures, and could not be corrected manually more than 15 degrees. It was obvious, therefore, that no more than 15 degrees could be obtained as the result of the operation. This meant considerable persistent deformity. Surgical correction of this deformity has not, in general, resulted in much improvement, either cosmetically or functionally, other than a slight stability of the forearm and hand. The deformity has not been well corrected.

Follow-up roentgenograms revealed good union between the radius and the shaft of the transplanted fibula with what appeared to be a patent epiphysis.

The recent roentgenograms and photographs represent the follow-up of one and a half years (Figs. 2-D and 2-E). Pronation and supination are each 50 per cent., and there is also wrist motion.

Criticism should be made of the procedure in two respects. The transplant was somewhat too short, and a longer one could have been applied without difficulty. It will also be noted (Fig. 2-D) that there is still some persistent bowing in the upper third of the ulna. It is contemplated that this might be corrected by subsequent osteotomy of both bones, and further skeletal traction. These errors were rectified in the next case attempted.

CASE 3. This child was first seen at the age of twelve, at which time a deformity of the right forearm was noticed (Fig. 3-A). There was a complete absence of the radius, some of the radial components of the carpus, and of the first metacarpal and thumb. The opposite forearm was normal. There was also marked radial angulation of the hand, and dislocation of the carpus in relation to the lower end of the ulna, which was prominent dorsally and ulnaward. A large skin callus had developed over the prominent lower end of the ulna. The child was wearing a molded leather and metal support to help maintain the hand in improved relationship.

In this case, a similar operative procedure was attempted except that, since no radius was present, the graft was inserted into the ulna at the approximate site of the osteotomy. Skeletal traction was applied for six weeks. A remarkable realignment of the hand in relation to the forearm was obtained. Osteotomy was then accomplished in the ulna at the site of maximum bowing, and was transfixed with Roger Anderson external fixation, including the Kirschner wire.

This, it was felt, was a luxury, but maintained the hand and arm in good correction. It is unnecessary, providing the arm is kept in skeletal traction while the osteotomy unites.

Upon complete union of the ulna, removal of the pins, and the healing of the pin sites, the third stage was attempted two months after the osteotomy.

No difficulty was encountered in inserting the transplanted upper end of the fibula in relation to

the carpus. There was, however, slight diastasis between the lower end of the ulna and the transplanted fibular graft. It was maintained by two vitallium screws placed transversely through the forearm, one at the site of insertion in the ulna, and the other in the distal half (Fig. 3-D).

FIG. 3-A
Case 3. Photograph before correction.

FIG. 3-B
Roentgenograms before correction.

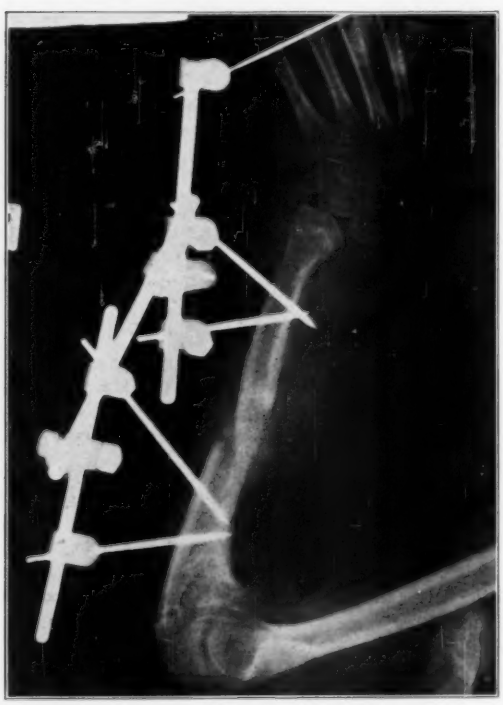

FIG. 3-C
External fixation following osteotomy.

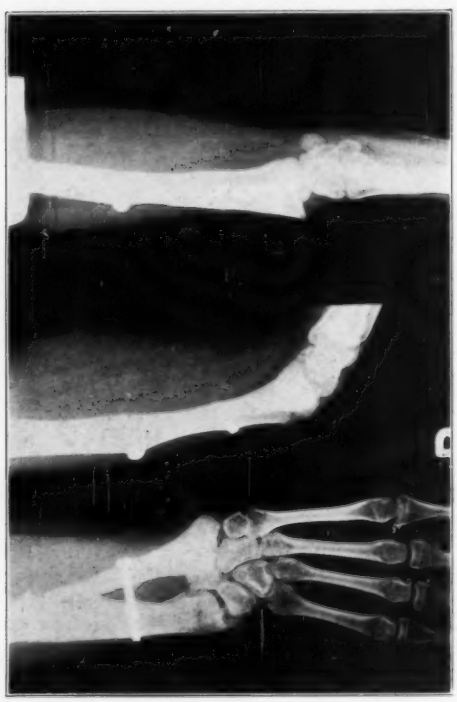

FIG. 3-D
Roentgenograms one year after final stage of correction.

FIG. 3-E
Photograph taken one year after final stage of correction.

FIG. 3-F
Photograph showing wrist motion.

In this case, the correction has been better than in the first one attempted. It does not appear, however, that the epiphysis of the fibula has remained patent; but, after one year, there is no discrepancy in the length of the lower end of the ulna in relation to the transplanted fibular graft. Flexion and extension of the wrist are possible (Fig. 3-F). There has been no tendency to recurrence of the radial deviation. The forearm at the time of the third procedure was aligned in mid-pronation. The functional end result in this case is excellent, although no rotary motion of the forearm is obtainable.

SUMMARY

1. Congenital absence of the radius, while uncommon, has been repeatedly reported in the literature.

2. The deformity is often accompanied by other evidences of congenital deformity of the hand, and, in one case, a direct hereditary linkage with the maternal grandmother is shown.

3. The technique described is a three-stage procedure,—namely, skeletal traction, ulnar osteotomy, and fibular transplant.

4. The technique is unique in allowing forearm rotation and wrist motion, when part of the radius is present; and it results in an extremely improved appearance.

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BRITTAIN ISCHIOFEMORAL ARTHRODESIS

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In 1941, Brittain described a method of arthrodesis of the hip, in which a large tibial graft is inserted into a cleft in the ischium, through an oblique osteotomy. The shaft of the femur is then displaced medially toward the ischium, supporting the graft and "short-circuiting" the diseased hip joint. Brittain, in his original paper[1], reported thirty-five cases of hip-joint disease in which arthrodeses were done by this method, with success in 88 per cent.; re-fusion by the same method was necessary in three cases. In Brittain's series, sixteen cases were of infectious or osteo-arthritic origin, while nineteen were cases of tuberculosis.

This method of arthrodesis utilizes the principle that, for stability and bone growth, compression is more efficient than tension[2]. Atrophy of the soft parts on the medial side of the thigh, which occurs during immobilization in a cast, places a strain on the iliofemoral graft, and may result in possible failure of the operation; but this same process, by increasing the pressure, makes the ischiofemoral arthrodesis only more secure. In addition, progress of the disease will not interfere with ischiofemoral arthrodesis, as it does with iliofemoral arthrodesis, and further destruction of the head with increasing dead space will not place an added strain on the graft.

It is the purpose of this paper to report the writers' experiences with this method, and to describe minor modifications in technique which have been evolved. Since March 1943, nine patients at this Clinic have had arthrodeses by this method for tuberculosis of the hip, with a total of twelve hips operated upon, since three were cases of bilateral hip tuberculosis.

Indications

It is universally recognized that no one method of arthrodesis of the hip is applicable in all instances where this procedure is indicated. The choice of method will vary with the underlying disease process, its stage and exact extent, and with the patient's age and general condition.

The usual extra-articular, intra-articular, and "combined" arthrodeses of the hip often involve difficulty and considerable risk. This is especially true in elderly patients, and in patients with tuberculosis in which there is still some activity and in which there is considerable destruction of the hip and the ilium. The incidence of failure of arthrodesis in these latter cases is relatively high, and, if the full extent of progression of the process has not taken place, further destruction may jeopardize the result.

Although operation in an area of tuberculous disease does not necessarily result in failure, extra-articular arthrodesis is to be preferred, if there is a reasonable chance of success.

Ischiofemoral arthrodesis offers an alternative extra-articular method of obtaining a bony fusion between the femur and the pelvis. Trumble described a method by which this may be accomplished, but his procedure requires an extensive exposure in the gluteal region, with isolation of the sciatic nerve and insertion of a large tibial graft in a bed anterior to this nerve. This procedure requires adequate bony contact and soft-tissue fixation between the head and neck of the femur and the acetabulum.

Brittain's method of ischiofemoral arthrodesis can be employed in any condition in

which fusion of the hip is indicated. However, it is of particular value in cases of tuberculosis where the involvement is primarily acetabular, with upward extension into the ilium. Arthrodesis by the usual methods in such cases is difficult and frequently impossible, but with Brittain's method the graft is placed below the area of involvement. The tuberculous process rarely extends into the ischium, but if such a process were sufficiently advanced, it would, of course, be a contra-indication to the use of the Brittain method.

Due to the simplicity and ease with which the procedure may be accomplished, and to the absence of complications, it is possible by this method to arthrodese the hip in a patient in whom a more extensive procedure would otherwise be contra-indicated, because of age or general condition. This method is particularly useful in children with tuberculosis of the hip, for these patients are frequently in poor general condition. Major surgical procedures are, therefore, not indicated, even though the patients have been carefully prepared for surgery. In none of our cases was there postoperative shock, excessive hemorrhage, or nerve or visceral damage.

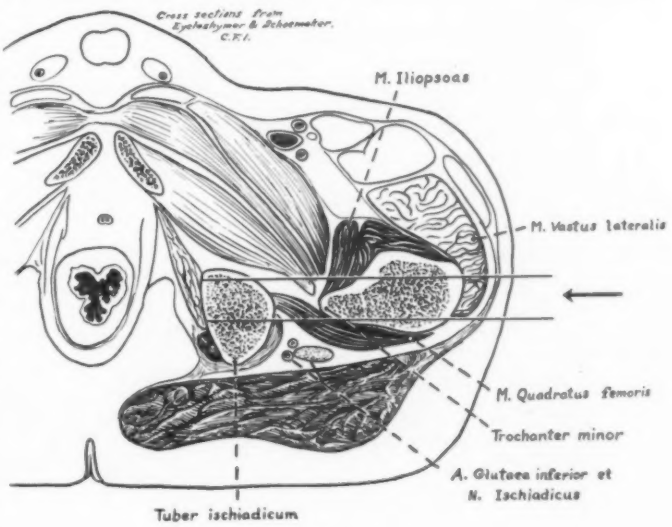

FIG. 1

Regional anatomy, showing path of osteotome and location of graft. (Composite cross-section from Eycleshymer and Schoemaker.[3] *Reproduced by permission from D. Appleton & Co.*)

Since resubstitution of the graft is necessary before fusion can be complete, it is felt that the method is better suited to children than to adults, because the bone-regenerating and bone-revascularizing power in children is much greater than in adults. Consequently, it is only reasonable that arthrodesis, with an autogenous graft, should occur with greater rapidity in children. However, in Brittain's series, nineteen of his thirty-five patients were above the age of eighteen, his oldest patient being sixty-three years of age at the time of operation. In our series, eight of the nine patients were children whose ages varied from eight to thirteen. In the one adult, aged fifty-two, the graft became involved by the disease; thus a conclusion as to the length of time required for resubstitution of the graft in an adult could not be reached.

Regional Anatomy

It might seem that this procedure would be hazardous, since it is done "blindly" through a lateral approach. However, roentgenographic control is used throughout, and a study of the regional anatomy reveals that the path through which the osteotomy is done and the graft inserted is quite safe, as long as all work is performed in the coronal plane (parallel with the table). Anteriorly, the femoral vessels are well forward, while posteriorly the sciatic nerve is safely out of the way. Medially, the adductor structures are not in the vicinity of the operative path (Fig. 1).

It might also appear that the graft could pass through the obturator foramen; but this, too, is an anatomical impossibility, because of the obliquity of the osteotomy in the one plane and the obliquity of the obturator foramen in the other plane. Penetration of the graft into the pelvis has not caused complications, and any penetrating portion is eventually absorbed (Figs. 2-B, 2-C, 4-B, and 4-C).

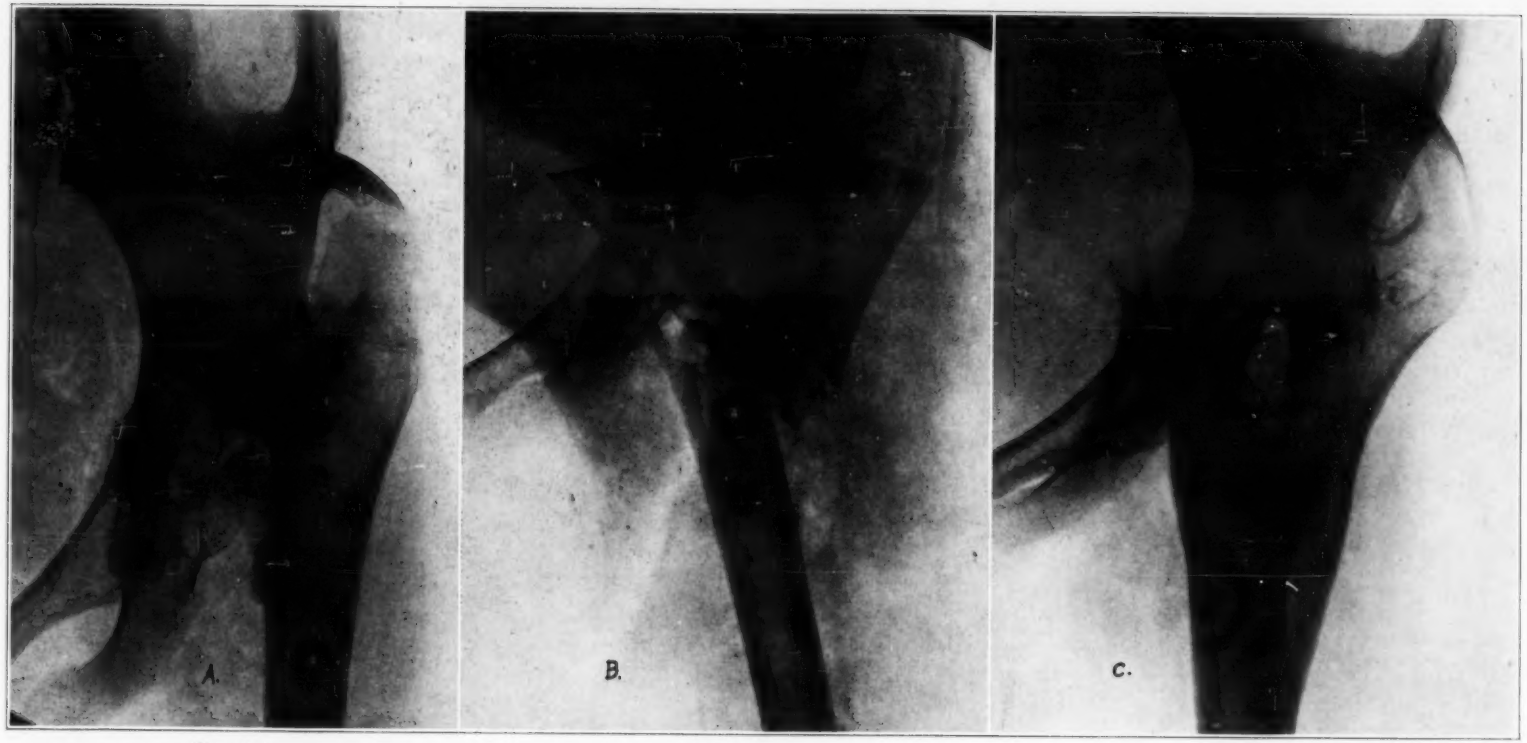

FIG. 2-A

J. M., female, aged thirteen. Tuberculosis of hip of eleven years' duration. Failure of fusion following iliofemoral arthrodesis.

FIG. 2-B

Immediate postoperative roentgenogram, showing position of graft and femoral fragments. Note intrusion of graft into pelvis.

FIG. 2-C

Result fourteen months after operation. Solid fusion has occurred, and patient now participates in normal activities without support. Note absorption of intrapelvic portion of graft, and adduction which occurred postoperatively.

THE METHOD

The patient is immobilized on the fracture table with a cassette holder under the hips, as for the insertion of a Smith-Petersen nail for a central fracture of the neck of the femur. A preoperative roentgenogram is made before the skin is prepared. A lateral longitudinal muscle-splitting incision is employed, extending down from the region of the abductor tubercle of the femur for a distance of three to five inches (7.5 to 12.5 centimeters). The shaft of the femur is exposed subperiosteally. A three-millimeter drill point is then drilled obliquely through the shaft of the femur at a predetermined level, utilizing the abductor tubercle as a localizing aid, and passing upward at an angle of 40 to 45 degrees with the shaft of the femur. The drill point is then removed, and a 1.5 millimeter guide wire (such as is used with the cannulated Smith-Petersen nail) is passed by hand through the drill hole in the shaft of the femur and on through the soft tissues in a plane parallel with the table, until the ischium is encountered. A Jacobs chuck drill is placed on the guide wire, which is then drilled into the ischium for 1.5 to two centimeters. A check-up anteroposterior roentgenogram is made to ascertain the position and the depth of the guide wire.

While this film is being developed, a full-thickness tibial graft is removed, including the anterolateral and posteromedial crests, the approximate length of the graft having been determined by measurements from the guide wire.

If alteration in placement of the guide wire is unnecessary, the femur is obliquely osteotomized alongside the guide wire, using a long, thin osteotome. The osteotome is then passed on into the ischium in the coronal plane. By a decreased sense of resistance, it is easy to determine, while driving the osteotome through the ischium, just when the medial cortex of the ischium is perforated. The guide wire is removed, and the osteotome is "rocked" up and down until an adequate cleft is made in the ischium. The handle of the osteotome is then depressed, and the graft, beveled on its presenting end, and with its medullary surface down, is inserted along the superior surface of the osteotome. The osteotome is withdrawn as the graft reaches the ischium, so that the graft can be driven into the prepared cleft. Next, the periosteum around the femur at the osteotomy site is completely severed, so that the distal fragment can be displaced medially. This is an essential step, since the periosteum is quite fibrous and tough in children, and, unless it is completely cut, medial displacement of the shaft of the femur is quite difficult. Medial displacement of the shaft is accomplished by traction, abduction, and direct pressure. When the displacement has been satisfactorily accomplished, the leg is placed in the position of choice, and

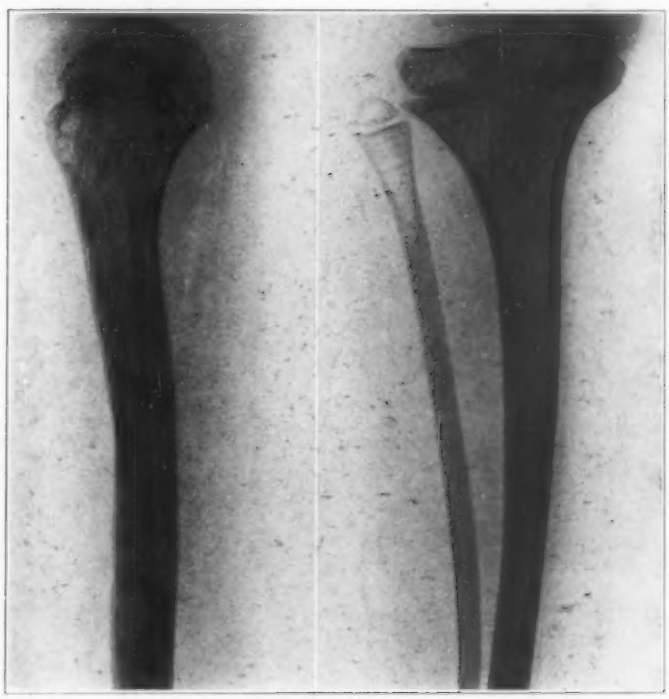

FIG. 3

B. T., male, aged eight. Both views of tibia thirteen months after removal of graft. Note reformation of cortex.

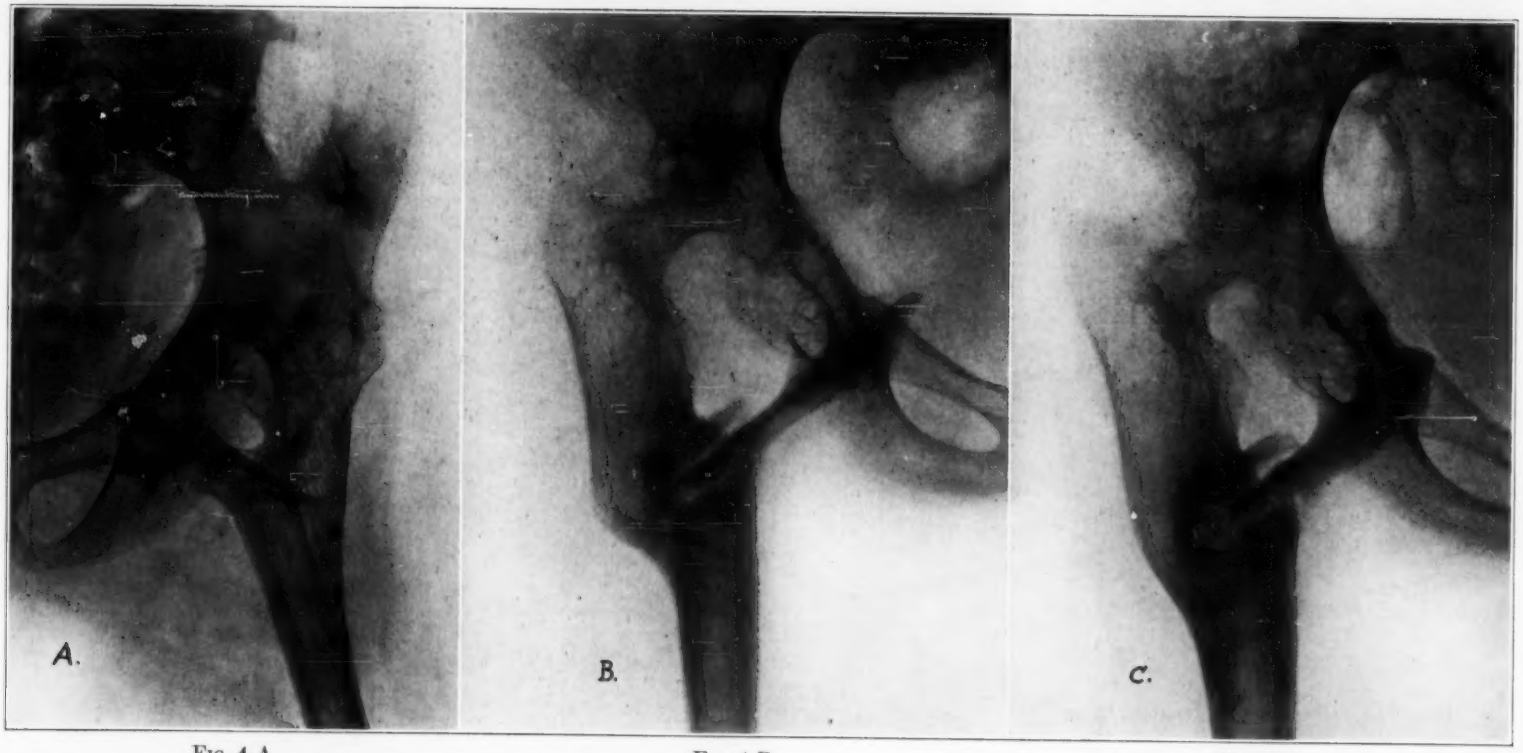

FIG. 4-A

M. D., female, aged eight. Bilateral tuberculosis of hip of five years' duration. Patient had had iliofemoral arthrodesis elsewhere, with failure. Fracture of graft occurred eight weeks after operation, while patient was being prepared for operation on opposite hip. This roentgenogram made eight months after fracture.

FIG. 4-B

K. M., male, aged eleven. Tuberculosis of hip of eight years' duration. Roentgenogram made four months after operation shows absorption about graft as result of inadequate immobilization. However, osteotomy has solidly united. Shaft inadequately displaced medially.

FIG. 4-C

Same patient as Fig. 4-B, ten months after operation. Note bony proliferation about lateral aspect of graft and absorption of the intrapelvic portion of graft.

final check-up roentgenograms are made. The wound is closed in a routine manner, and a full, double spica cast is applied, extending from the nipple line to the toes bilaterally in children, and to the knee on the opposite side in adults. If difficulty in maintaining the medial displacement of the shaft is encountered, the surgeon may apply the cast in sections, as suggested by Brittain,—that is, incorporating the leg up to the osteotomy site separately, and then completing the cast, after a satisfactory position of the fragments has been obtained. This method has the added advantage of preventing any valgus strain on the knee. In some instances, wide abduction of the leg may be necessary to maintain the displacement; in such cases, the cast may be changed after three weeks, and the leg brought into the optimum position without loss of medial displacement. Final check-up roentgenograms are made after the cast has been completed.

FIG. 5-A

H. B., male, aged fifty-two. Tuberculosis of the hip of eight months' duration. Roentgenogram made two months after operation. The graft has become involved by the disease and sequestration is occurring.

RESULTS AND OBSERVATIONS

In this series of nine cases, with twelve hips arthrodesed, only seven cases (ten hips) can be considered, since two unilateral cases are too recent. There were no draining sinuses

FIG. 5-B

Appearance of hip nine months after operation. Note apparent progression of fusion despite sequestration of lateral portion of graft.

FIG. 5-C

Roentgenogram seventeen months after operation. Further progress of fusion has taken place. Definite sequestration of lateral portion of graft has occurred. Note improvement in condition of head of the femur. Hip is clinically arthrodesed, and the patient has been walking in a brace for six months.

FIG. 6

W. R., male, aged nine. Bilateral tuberculosis of hip of six years' duration. Appearance thirteen months after last operation. Note variation in obliquity of grafts.

at the time of operation. Our follow-up period varies from eleven to twenty-three months; and of the ten hips, six are solidly arthrodesed clinically and roentgenographically.

At the present time, one hip shows sequestration of a portion of the graft (Figs. 5-A, 5-B, and 5-C), with involucrum formation about it, so that this result will undoubtedly also be successful. The infection was due primarily to the extension of the disease to the graft, with secondary infection after sinus formation.

Two of the grafts have fractured, and another graft shows absorption about the outer end. These complications will be discussed below.

In the present series, the following observations have been made:

1. *Obliquity of the Osteotomy and Graft*: The series is too small to determine the influence of obliquity of the graft on the outcome. However, it has been noted that an obliquely placed graft aids in medial displacement of the shaft of the femur (Figs. 2-A, 2-B, and 2-C). In fact, later roentgenograms may show further medial displacement of the shaft than was present immediately after operation.

2. *Size of the Graft*: Removal of such a large graft was at first done with some hesitancy, but the rapidity with which the tibia reformed in children has been most satisfying (Fig. 3). In one child there was a fracture of the donor leg, but, as stated above, in children the cast should incorporate the donor leg to guard against such a complication, as well as to increase the efficiency of the cast in immobilizing the hip. The fractures of the graft which occurred (Fig. 4-A) and the absorption about the outer end of the graft which occurred in one case (Figs. 4-B and 4-C) were the results of inadequate immobilization. At the present time, it appears that the arthrodesis in these cases may eventually succeed, if immobilization is continued for a sufficiently long period of time. If arthrodesis fails in these cases, there is no contra-indication to re-arthrodesis by the same method.

3. *Location of the Graft in the Ischium*: It must again be stressed that the cleft

in the ischium should be placed sufficiently low to avoid inserting the graft in a diseased area, with resulting involvement of the graft by the disease (Figs. 5-A, 5-B, and 5-C).

4. *Displacement of the Shaft of the Femur*: Although in our earliest cases the importance of displacing the shaft of the femur adequately was not realized, calamities cannot be directly attributed to this. However, displacing the shaft medially adds to the stability of the arthrodesis, lessens the strain on the graft during fusion, and further ensures success, because of contact of the central portion of the graft with viable bone (Figs. 4-B and 4-C).

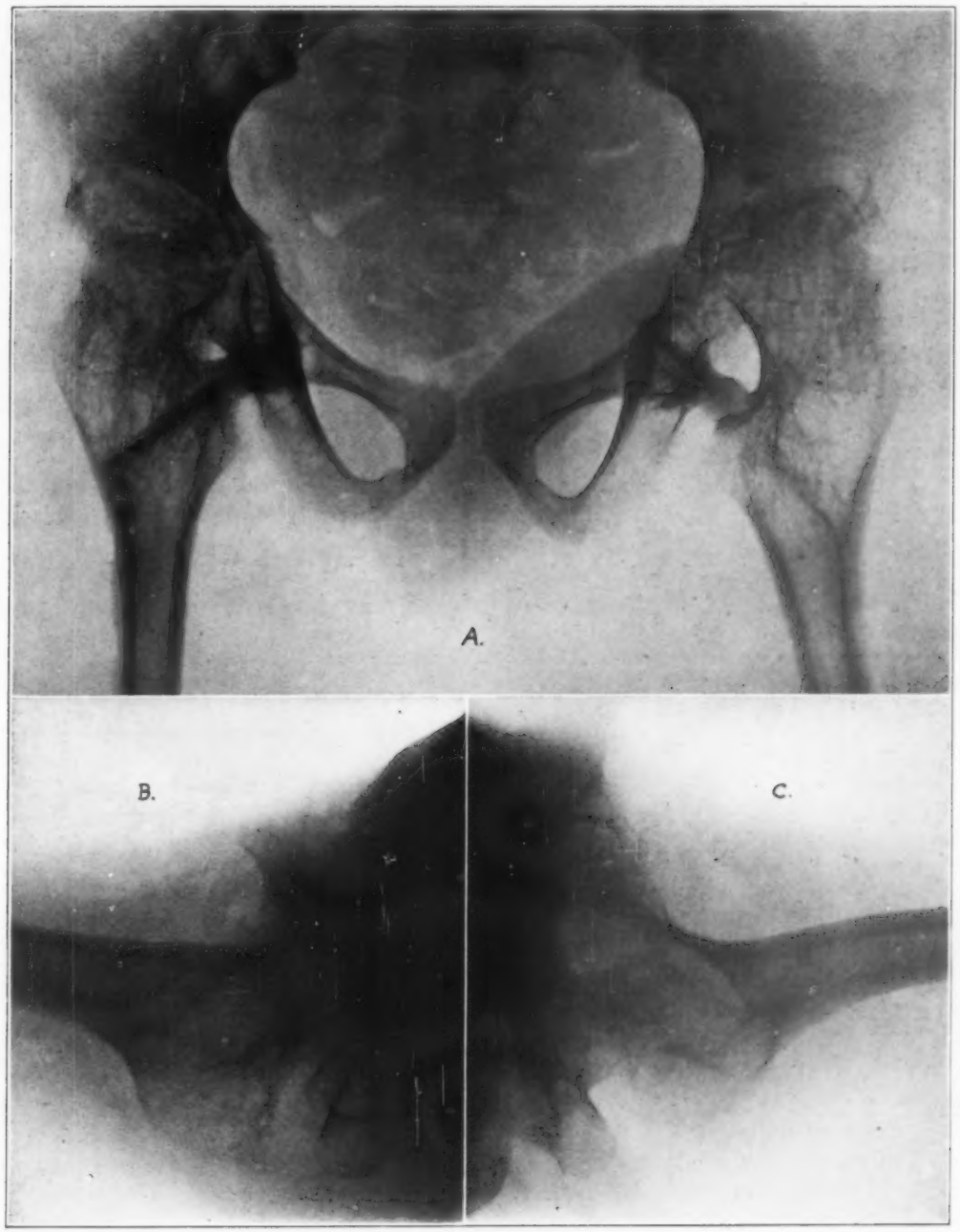

FIG. 7

B. T., male, aged eight. Bilateral tuberculosis of hip of five years' duration. *A*: Appearance thirteen months after last operation. Weight-bearing has not been resumed. *B* and *C*: Lateral views of hips.

5. *Position of the Hip*: In the one adult patient, the lower extremity was placed in the position of optimum function,—that is, 15 degrees of abduction, 20 degrees of flexion, and slight external rotation. In the remainder of the cases in children, the legs have been placed in abduction of 25 to 30 degrees, as adduction was anticipated with growth. However, in our cases, relatively little adduction from the original position has occurred as yet, although it is too early to determine to just what extent this will eventually take place. If necessary, a subtrochanteric osteotomy can be done at some later date to correct the weight-bearing alignment of this extremity.

6. *Bilateral Arthrodesis of the Hip*: This was done in three cases (Figs. 6 and 7). The healing of a tuberculous hip is accomplished only by arthrodesis or by excision. The latter is a formidable and mutilating procedure that is prohibited in most cases, whereas arthrodesis results in a stable hip with a minimum of deformity. Conservative attempts to maintain motion in one hip in cases of bilateral tuberculosis are dangerous and almost universally unsuccessful. Bilateral arthrodesis is to be preferred in such cases, despite the many disadvantages. This is especially true where financial considerations prevent prolonged hospital treatment, followed by many years of frequent and careful observation.

7. *Period of Immobilization*: In our cases, the site of arthrodesis has usually consolidated in from three to four months, but immobilization should be continued until the hip joint is solidly fused and the disease process is healed. As Brittain has stressed, this operation is only another method of enforcing rest for a tuberculous joint, and ambulation should not be allowed until healing of the disease itself is complete.

CONCLUSIONS

1. The Brittain ischiofemoral arthrodesis performed under complete roentgenographic control is simple, safe, extra-articular, and results in successful arthrodesis of the hip in a high percentage of cases.

2. Six of ten hips treated by this method and followed for a minimum of eleven months have fused. All of the failures can be attributed to errors in technique, rather than to failure of the method itself.

3. The Brittain method is especially applicable to children with tuberculosis of the hip, since consolidation of the osteotomy and revascularization of the graft occur rapidly, and the operation can be done in children who would not tolerate a more difficult and shocking procedure.

4. Our experience with this method in adults has not been sufficient to permit an opinion as to its value, although Brittain has successfully employed it in adults.

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ASEPTIC NECROSIS OF THE ASTRAGALUS FOLLOWING ARTHRODESING PROCEDURES OF THE TARSUS

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Aseptic necrosis of the body of the astragalus [talus] frequently occurs in major fractures and fracture-dislocations of this bone, because of the paucity of its blood supply. Several anatomical studies of the arterial circulation of the astragalus have recently been published. McKeever's is the most detailed. According to him, "the entire vascular supply of the astragalus is derived from branches of the anterior tibial artery. There is evidence also that the artery, which eventually breaks up into several nutrient arteries, is carried in the dense astragaloscaphoid ligament (ligamentum talonaviculare dorsale), which extends as a broad band from the dorsal surface of the neck of the astragalus to the dorsal periphery of the scaphoid. In this ligament the artery divides into several (two to four) smaller arteries which perforate the superomedial aspect of the neck of the astragalus, where foramina are clearly present. No evidence of arteries perforating from either the posterior or the anterior calcaneoastragalar ligament or from the internal calcaneoastragalar ligaments in the subastragalar joint was apparent. In no instance was it possible to demonstrate arteries throughout the body of the astragalus."

Lipscomb and Ghormley describe the arteries to the astragalus as branches of the dorsalis pedis, entering the bone at the lateral aspect of the neck. According to them, a minor supply also enters through various smaller branches at the ligamentous and capsular attachments. Phemister, Sneed, and Watson-Jones differ on the finer details of the blood supply to the astragalus, but all agree on the precarious location of these vessels, an arrangement not dissimilar to that encountered about the head and neck of the femur.

It seems surprising, therefore, that aseptic necrosis of the astragalus has not been mentioned as a complication of arthrodesing procedures of the tarsus. It would appear inevitable after extensive resection of the head and neck of this bone. Our findings indicate that it occurs not too infrequently,—twice in one series of seventeen cases, and three times in another series of forty-four cases. No statistical significance can be ascribed to these figures, since the occurrence of aseptic necrosis depends on the extent of resection of the head and neck of the astragalus, and probably also on the extent of periosteal stripping at the operation. The latter factor is increased in re-operations, which as a rule require a more extensive exposure. In our group of five cases, two followed secondary arthrodesing procedures, and all involved extensive resection of the head and neck of the astragalus. Minor degrees of increased density and temporary mottling of the body of the astragalus were noted in several other cases. They did not persist long enough to warrant restriction of weight-bearing or immobilization beyond the usual period, and no harmful results ensued.

CASE REPORTS

CASE 1. A. A., a boy, aged fourteen, was admitted to the Mount Sinai Hospital for correction of a paralytic calcaneovalgus deformity of the left foot. On September 16, 1942, a reverse-type Lambrinudi procedure was performed. The peroneal muscles were transplanted into the os calcis. Extensive remodeling of the tarsal bones was necessary to correct the deformity, and the head of the astragalus was completely excised. The time required for operating was one hour and forty-five minutes. Following the operation, the patient was unable to move his toes, and had complete anaesthesia of the toes and of the distal foot. This was correctly ascribed to tourniquet paralysis, from which the boy recovered promptly. Later, superficial skin necrosis about the incision necessitated several changes of plaster, but this also healed readily. As early as three weeks after operation, the body of the astragalus was found to be denser than the surrounding bones upon roentgenographic examination (Fig. 1-A). This was interpreted as aseptic necrosis, and became more marked during the following months. No weight-bearing

FIG. 1-A

Case 1. Left foot three weeks after triple arthrodesis of reverse Lambrinudi type, with transplant of peroneals into os calcis for paralytic calcaneovalgus. Extensive resection of head and neck of astragalus, with suggestive increase of density in this bone.

FIG. 1-B

Three months after operation, the astragalus was definitely the site of aseptic necrosis. Note marked relative density and mottling of astragalus in comparison with atrophy of remaining bones of foot.

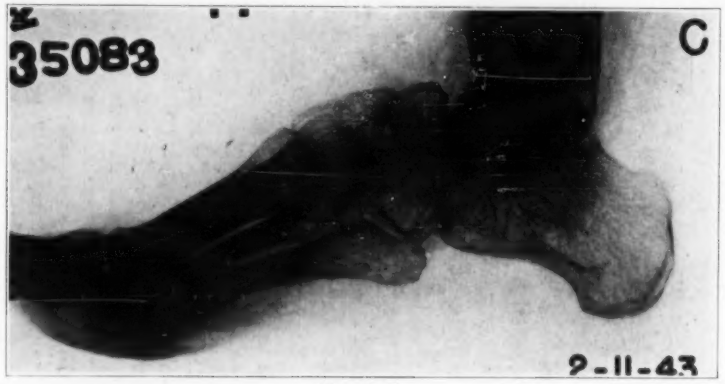

FIG. 1-C

Five months after operation, there was good fusion and beginning revascularization.

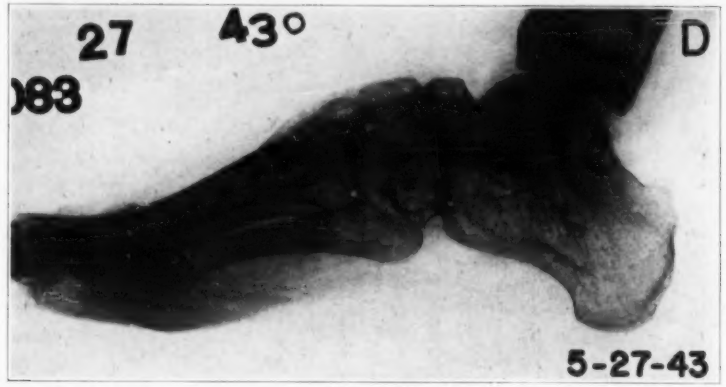

FIG. 1-D

Eight and a half months after operation, advanced revascularization had taken place. Weight-bearing without cast was begun.

was allowed until March 1943, approximately six months after operation, when considerable revascularization of the astragalus was noted. This boy was last seen eighteen months after operation, when the result of the procedure was judged excellent. The patient's gait was much improved, and he was able to walk long distances. The subastragalar and mid-tarsal joints were clinically fused in good position, with adequate backward displacement of the foot and good strength in the transplanted muscles. Roentgenographic examination at this time showed solid bony union of the arthrodesed joints. The astragalus was completely revascularized. There was no deformity of the remaining body, and no evidence of irregularity of the surface of the ankle joint.

Case 2. C. O., a woman, aged forty-eight, was admitted to the Mount Sinai Hospital for correction of a paralytic equinovalgus deformity of the left foot. A modified Lambrinudi procedure was performed on June 18, 1938. The head and neck of the astragalus were completely resected. Because of persistent

Fig. 2-A

Case 2. Left foot two and a half months after operation. Modified Lambrinudi type subastragalar arthrodesis was performed for paralytic equinovalgus, with extensive resection of head and neck of astragalus (the calcaneocuboid joint was spared).

Fig. 2-B

Eighteen months after operation. A secondary mid-tarsal arthrodesis had been done nine months postoperatively. Note diminution of height of astragalus and relative density of this bone.

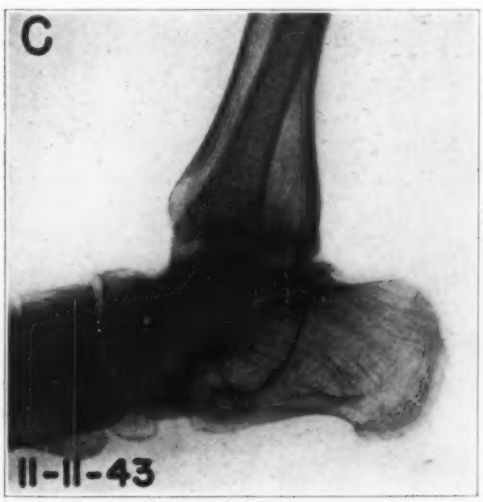

Fig. 2-C

Showing further collapse and compression of astragalus at the site of aseptic necrosis. There was incongruity of the tibial and astragalar articular surfaces in the ankle joint.

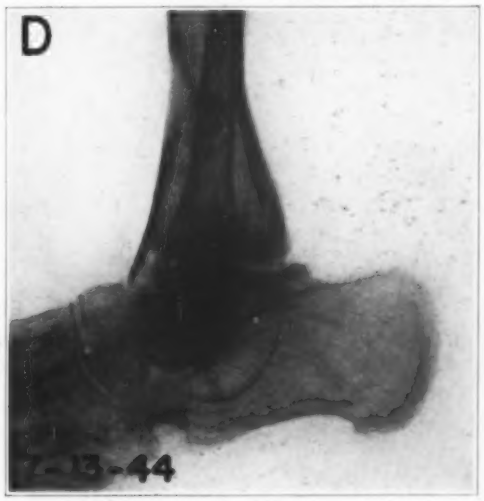

Fig. 2-D

Six months after ankle fusion, which was necessitated by pain and arthritis in ankle joint.

FIG. 3-A

Case 3. September 7, 1943. Right foot twelve years after posterior subastragalar fusion had been performed with a Campbell bone block for paralytic drop-foot. The mid-tarsal joint was intact.

FIG. 3-B

October 26, 1943. Roentgenogram taken immediately after triple arthrodesis (Ryerson type) for paralytic equinovarus, with extensive resection of head of astragalus.

FIG. 3-C

Three months after operation, showing diffuse mottling and relatively greater density of remaining astragalus, with decrease in height of bone.

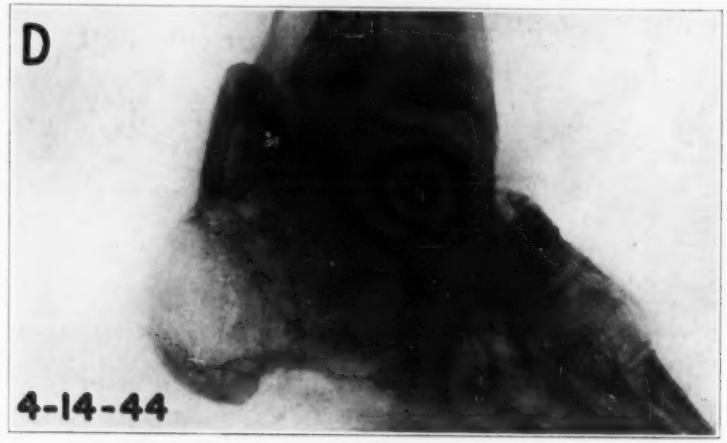

FIG. 3-D

Six months after operation. Patient is ambulatory, and weight-bearing has been permitted for three months since removal of plaster. Showing increased density and collapse of astragalus, as well as increased incongruity of articular surfaces of ankle. This patient will probably require ankle fusion.

pain related to the mid-tarsal joint, a secondary wedge resection of this joint was necessary. This was done on March 18, 1939, nine months after the first operation. Weight-bearing was allowed four months later. No attention was paid to the avascular necrosis of the body of the astragalus, which had occurred following the second operation. This bone went on to progressive collapse under unprotected weight-bearing. A severe degenerative arthritis of the ankle developed with marked disability and pain. Despite various conservative measures, including bracing, arthrodesis of this joint had to be undertaken. The ankle fusion was done on January 22, 1944, utilizing a bone graft from the tibia in addition to the usual intra-articular technique. Solid bony ankylosis was accomplished in eight months. When last seen, thirteen months after ankle fusion, the patient's gait was much improved. There was minimal residual pain, and the patient was ready to return to light work.

CASE 3. R. W., a man, aged twenty-eight, was admitted to Bellevue Hospital for correction of a severe equinovarus deformity of the right foot. In 1931 a posterior subastragalar arthrodesis with a Campbell bone block had been done for paralytic equinus, which was the result of severance of the peroneal nerve at the neck of the fibula, in an operation for osteomyelitis of that bone. This operation for the drop-foot was only partially successful. On October 25, 1943, an external T-shaped wedge was removed to correct the deformity. The subastragalar joint was found partly fused, and it was revised. The mid-tarsal joint was also arthrodesed. Weight-bearing in plaster was allowed six weeks after the operation, despite the aseptic necrosis of the astragalus which was noted in retrospect. This bone collapsed, and thus was initiated a severe arthritis of the ankle. When last seen eight months after operation, the patient complained of persistent pain in the foot and ankle.

FIG. 4-A

Case 4. June 5, 1941. Preoperative roentgenogram, showing paralytic or congenital varocavus deformity of right foot.

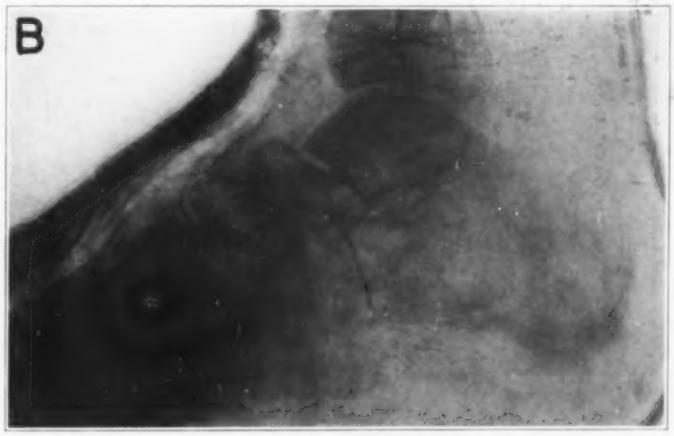

FIG. 4-B

September 5, 1941. Two months after triple arthrodesis (Ryerson type) with large dorsal wedge, including entire head and neck of astragalus.

FIG. 4-C

February 2, 1942. Seven months postoperative. Early revascularization of necrotic astragalus. No weight-bearing had been allowed because of later operation on left foot.

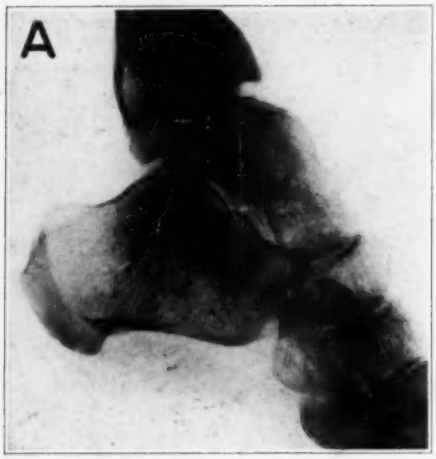

FIG. 5-A

Case 5. August 20, 1940. Preoperative roentgenogram of right foot, showing marked fixed paralytic equinovarus.

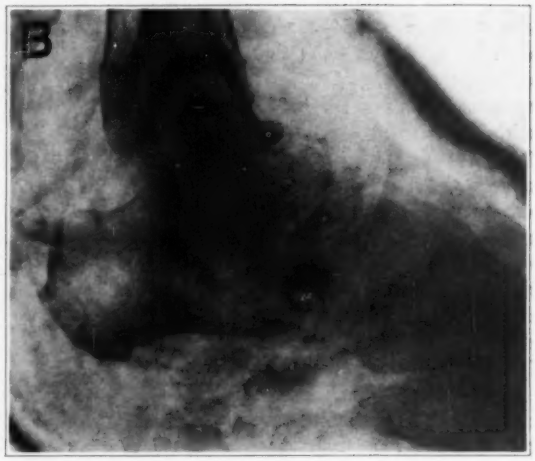

FIG. 5-B

September 17, 1940. One month after panastragalar arthrodesis, showing small size, increased density, and mottling of astragalus.

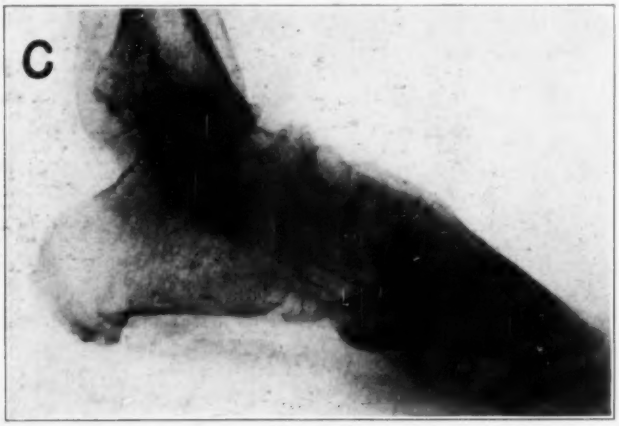

FIG. 5-C

March 12, 1941. Seven months after operation. Note further collapse and increased density of astragalus. Fusion of all joints was solid. Clinical result is probably satisfactory.

We have been unable to reach him for further study, but it is likely that painful symptoms will continue until ankle fusion is done.

CASE 4. W. W., a boy, aged thirteen, was admitted to Bellevue Hospital for extreme cavus deformity of the foot, probably congenital in nature. On July 7, 1941, the right foot was operated upon. A triple arthrodesis was done, and the entire head and neck of the astragalus were resected. To ensure adequate plantar flexion of the heel, double Kirschner-wire fixation in heel and tibia was used. A plantar fasciotomy had to performed. Good correction of the cavus was obtained, but avascular necrosis of the astragalus followed. Fortunately, because of a similar procedure on the left foot on October 6, 1941, the patient was not permitted to walk until six months after the first operation. By this time the astragalus of the right foot was well revascularized. (Incidentally this complication did not follow operation on the left foot in spite of a similar procedure.) When last seen, seven months after the last operation, the patient had no pain, and his gait was good.

It has been impossible to obtain any further follow-up. It is unlikely that this boy will have any difficulty with his ankle.

CASE 5. J. A., a woman, aged forty, was admitted to Bellevue Hospital for correction of a paralytic equinovarus deformity of the right foot. All muscles below the knee were paralyzed. The heel cord was contracted, permitting only 15 degrees of passive motion in the ankle. On August 21, 1940, a panastragalar arthrodesis was performed. No late follow-up is available, but roentgenograms approximately seven months after operation showed satisfactory fusion, despite aseptic necrosis and partial collapse of the remaining portion of the astragalus.

The next case is briefly mentioned for comparison of the rate of revascularization of an aseptically necrotic astragalus resulting from fracture.

CASE 6. A. V., a boy, aged fourteen, had fallen down a six-story elevator shaft one hour before admission to the Mount Sinai Hospital. Among other severe injuries he had sustained a severely com-

pounded comminuted fracture of the right tibia and fibula just above the ankle, and a slightly displaced fracture of the neck of the astragalus. When first seen he was in severe shock, which was given first consideration. Only a superficial débridement of the compound fracture was done, and gas gangrene later developed, necessitating wide drainage. The leg was saved; but during the critical period, reduction of the astragalus had to be neglected. The fracture healed, despite aseptic necrosis of the body of the astragalus. Roentgenographic study six and one half months after injury showed advanced revascularization, without ankle deformity. This boy has not been permitted to bear weight up to the present time, eight months after the fracture.

DISCUSSION

It is often necessary to resect the head of the astragalus to correct marked deformity of the foot. If extensive excision is unavoidable, it would appear advisable to remove additional bone from the scaphoid [navicular] or the cuneiform, rather than from the astragalus. In any case, the postoperative roentgenograms should be carefully inspected to discover possible aseptic necrosis of the astragalus. In the event of this complication, weight-bearing must be avoided. If unrestricted weight-bearing is allowed on a necrotic astragalus before revascularization takes place, this bone will collapse in whole or in part. The ankle-joint surface of the astragalus will become irregular, and lead to disturbance of the ankle joint with resulting osteo-arthritis; this may require arthrodesis for relief of pain and disability. In other words, the principle of safeguarding necrotic bone from weight-bearing until it has become revascularized must be strictly observed. As Phemister has expressed it: "Function hastens to some extent the rate and increases the extent of repair. It should,

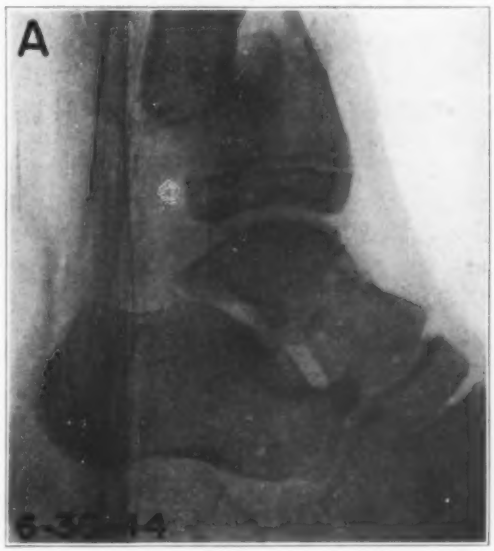

FIG. 6-A

Case 6. Fracture of the neck of the right astragalus.

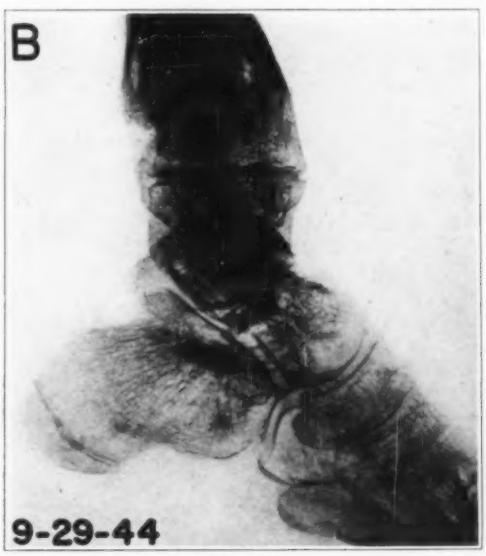

FIG. 6-B

Three months later, aseptic necrosis of the body of the astragalus was clearly shown by increased density of this part of the bone. No weight-bearing had been allowed.

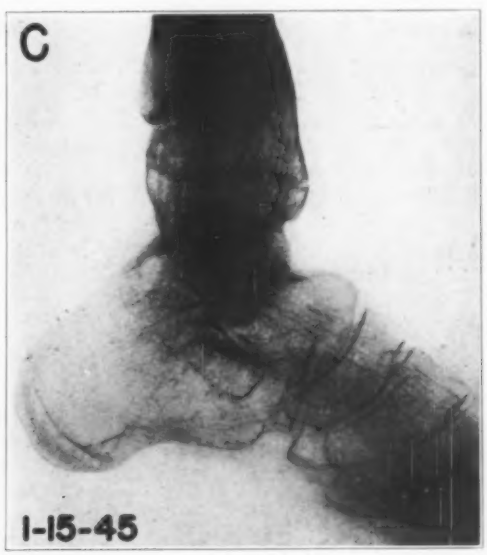

FIG. 6-C

Six and a half months after fracture, showing considerable revascularization.

however, be limited well within the strength of the necrotic bone and of the newly forming bone during the major part of the period of creeping substitution. If, in case of necrosis of the ends of the bones, there is too much weight-bearing, strain, or trauma in any form, there will be fracture of the necrotic bone or of the weak new bone . . ." While we have no large experience, revascularization of a necrotic astragalus appears to require about six to nine months in the average adolescent.

Where aseptic necrosis occurs in the presence of an ankle fusion, done as part of the primary procedure (panastragalar arthrodesis), the clinical significance of the lesion is much less, provided fusion of the ankle is successful. This may be delayed, because of the aseptic necrosis of the bone at the site of fusion, though revascularization in such an area is quite rapid.

CONCLUSIONS

1. Aseptic necrosis of the body of the astragalus is a not infrequent complication following arthrodesing procedures, requiring extensive resection of the head and neck of the astragalus, in order to correct severe deformities of the foot.

2. The frequency of this complication is sufficient to suggest that, when wide wedges are essential, the scaphoid should be sacrificed in preference to the astragalar neck.

3. Aseptic necrosis, if present, may be detected by roentgenographic examination as early as three to four weeks after operation. Suitable precautions should then be instituted.

4. Revascularization in the average adolescent takes place quite rapidly (six to nine months). Collapse of the body of the astragalus may be prevented by not permitting weight-bearing until this has been accomplished.

5. If premature weight-bearing is allowed, the body of the astragalus will become compressed, and the ankle-joint surface damaged, resulting in secondary osteo-arthritis of the ankle joint. This may require subsequent fusion for relief of pain and disability.

6. If ankle fusion is part of the primary procedure, aseptic necrosis of the astragalus is not as serious a complication.

NOTE: The authors wish to express their appreciation to Arthur Krida, M.D., for permission to use Cases 3, 4, and 5 from his Service at Bellevue Hospital.

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DIFFICULT FRACTURES OF THE NECK OF THE FEMUR TREATED WITH THE STUD-BOLT SCREW

Simplification of Technique

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In this paper the author wishes to present his results in the use of the stud-bolt screw for the treatment of ununited fractures or otherwise difficult cases of fracture of the neck of the femur.

Fig. 1-A

Fig. 1-B

Fig. 1-A: The parts of the screw are shown: *m*, the body; *n*, the flange; *o*, the nut. The helical thread *l* is very thin and penetrates the bone easily. This prevents turning of the head of the femur when the screw is driven home. The nut *o* is longer than the flange *n*; thus, when the nut is tightened, friction takes place only at the bottom and not at the top of the flange.

Fig. 1-B: The screw assembled.

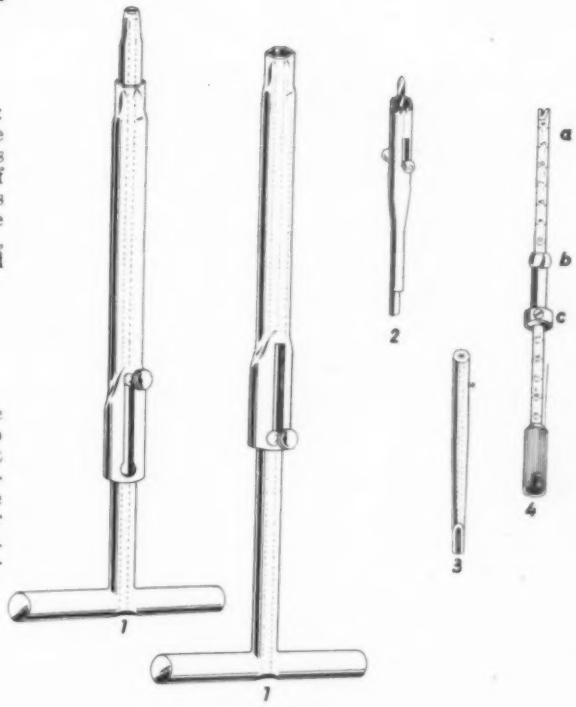

Fig. 2

Fig. 2

1: Double-action wrench; *2*: Trephine with guiding center pin; *3*: Attachment to receive the Kirschner wire and to prevent it from being pushed into the pelvis; *4*: Combined drill: *a* has the same diameter as the body of the screw (Fig. 1, *m*); *b* shows burr with the same diameter as the flange (Fig. 1, *n*); *c* is the collar which limits the penetration of the drill to the desired depth.

Since the publication of the writer's earlier article on this subject in *The Journal of Bone and Joint Surgery* in July 1940, we have operated upon eighty patients, using this technique, and the results have been excellent. Breaking or slipping of the screw has not been observed in any case.

The criterion in the classification of end results varies so widely that statistics in this particular instance are not always to be relied upon. The best way of demonstrating the quality of the results would be the reproduction of all of the roentgenograms, but the space required would make it difficult for our large series of cases to be presented. It would seem that the demonstration of a small number of difficult cases, in which good union and good function have been obtained, is more apt to prove the efficacy of the method than

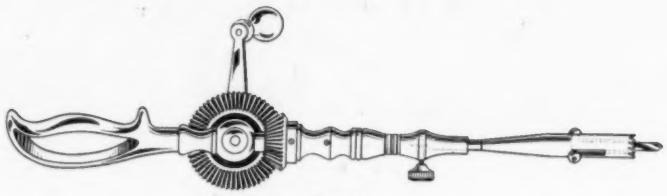

FIG. 3
Trephine attached to ordinary bone drill.

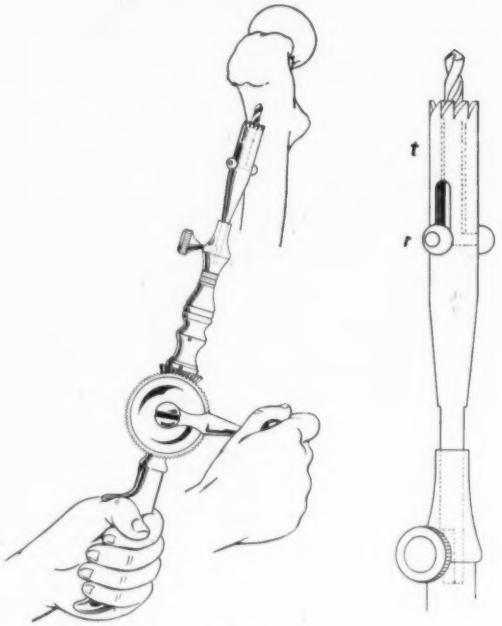

FIG. 4

FIG. 4
(*See below*)

Removal of a circular piece of the cortex using the special trephine. The diameter (*t*) is the same as that of the flange (Fig. 1,*n*). The movable piece (*r*) permits ejection of the fragment of bone which remains inside the trephine.

FIG. 5
Hole in the cortex made by the trephine.

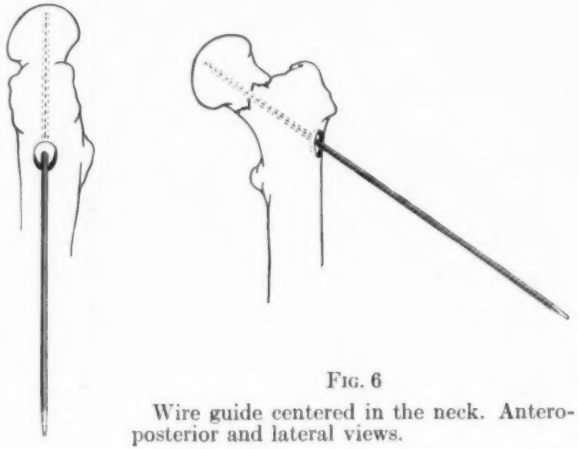

FIG. 6
Wire guide centered in the neck. Antero-posterior and lateral views.

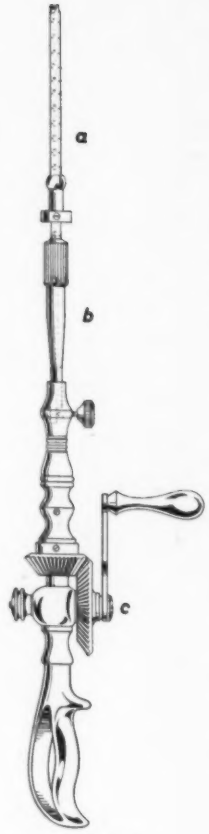

FIG. 7
The drill (*a*), attachment (*b*), and ordinary bone drill (*c*).

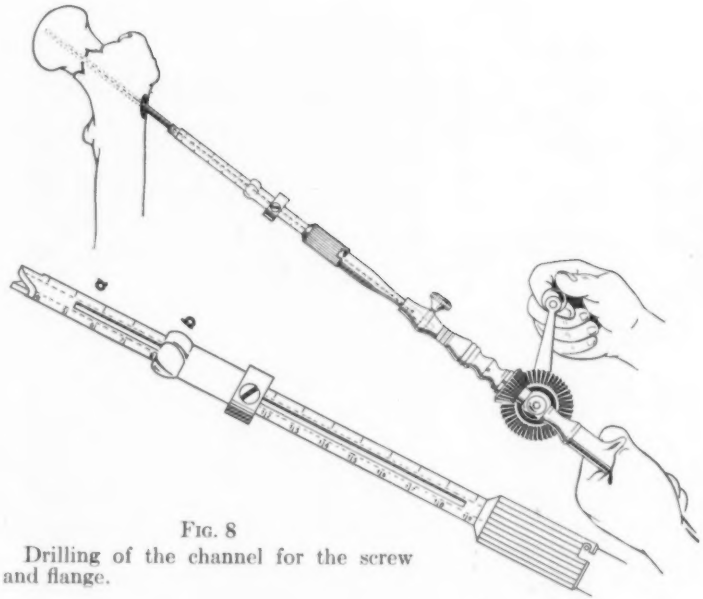

FIG. 8
Drilling of the channel for the screw and flange.

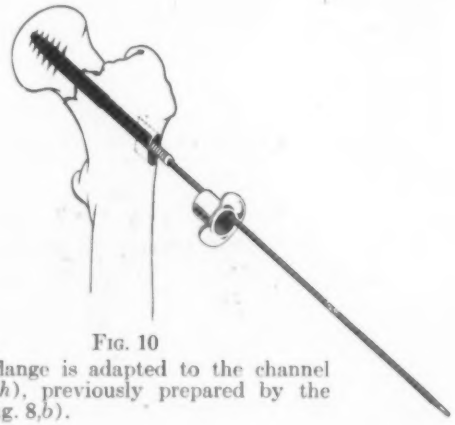

FIG. 10
The flange is adapted to the channel (Fig. 9,*h*), previously prepared by the burr (Fig. 8,*b*).

FIG. 11
Lateral view of the flange inserted.

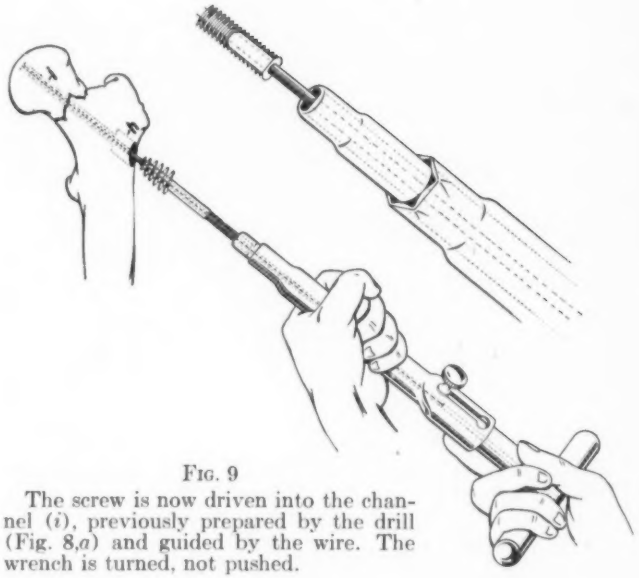

FIG. 9
The screw is now driven into the channel (*i*), previously prepared by the drill (Fig. 8,*a*) and guided by the wire. The wrench is turned, not pushed.

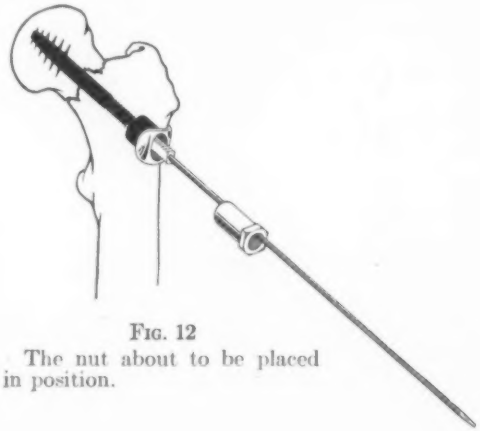

FIG. 12
The nut about to be placed in position.

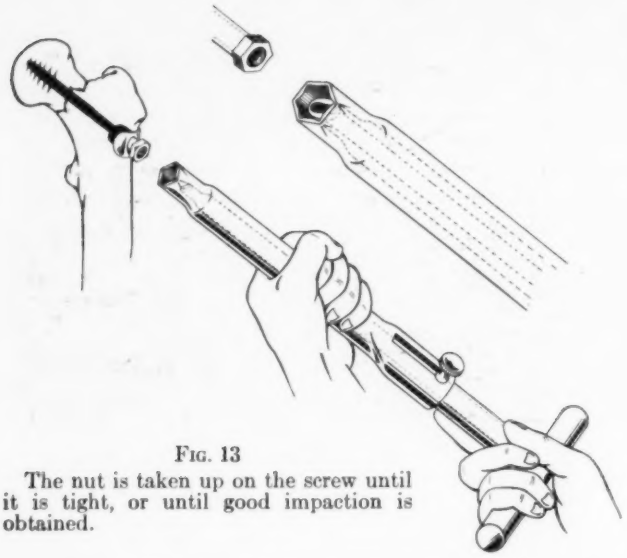

FIG. 13
The nut is taken up on the screw until it is tight, or until good impaction is obtained.

would be the presentation of a greater number of more common cases.

OPERATIVE TECHNIQUE

The writer's earlier technique has been considerably modified, so that the method now employed is one of the most simple of all techniques using screws, and it requires fewer special instruments. The electric motor was used in approximately twenty operations, and presented several disadvantages,—such as complexity and motor failures. Therefore, it seemed that an ordinary hand-driven bone drill would be more satisfactory.

The perforation of the hard cortex with the hand-driven burr is difficult, but, once the spongy bone has been reached, the procedure goes smoothly. Norman Roberts and Watson-Jones gouge a hole in the cortex beforehand, and we have devised a trephine for the same purpose. With the spongy bone exposed, the hand-driven bone drill works so easily that a motor can be dispensed with.

The drawings clearly illustrate the simplicity of the technique and instruments now in use.

CASE REPORTS

From a series of eighty operations, a small number of particularly difficult cases are submitted, in which union and perfect function have been obtained.

CASE 1. A. S. B., female, fifty-two years old, was first seen on April 4, 1941. Four months previously she had suffered a fracture of the neck of the left femur. Treatment had not been administered, and she was bedridden at the time of consultation.

Roentgenogram (Fig. 14-A) showed non-union of the unreduced fracture. Operation, using the technique illustrated, was performed on April 5, 1941. Plaster cast was not applied. Walking was begun on the thirtieth day after the operation. Frontal and axial roentgenograms (Figs. 14-B and 14-C) eleven months after the operation showed good union. Walking is normal.

CASE 2. J. B., Jr., male, forty-three years old, was seen on August 19, 1941. Three months previously the patient had suffered a fracture of the neck of the right femur. Traction had been applied for

FIG. 14-A
Case 1. April 4, 1941.

FIG. 14-B
March 10, 1942.

FIG. 14-C
March 10, 1942.

FIG. 15-A
Case 2. August 20, 1941.

FIG. 15-B
October 7, 1943.

FIG. 15-C
October 7, 1943.

FIG. 16-A
Case 3. September 23, 1941.

FIG. 16-B
March 27, 1944.

FIG. 16-C
March 27, 1944.

fifty days. The patient complained of pain and inability to walk without crutches. Roentgenogram (Fig. 15-A) shows the unreduced fracture in varus. Operation was performed on September 2, 1941. Cast was not applied. The patient began to walk on the fortieth day after operation. Roentgenograms (Figs. 15-B and 15-C) two years after the operation showed perfect union. Function of the leg is normal.

CASE 3. M. R., female, fifty years old, was first seen on September 23, 1941 (Fig. 16-A). The patient had fractured the neck of the left femur three months previously. Treatment consisted only of bed rest. Walking was impossible, and the patient complained of pain. Traction was applied for a week, and operation was then performed. Plaster cast was not applied. Walking was begun fifty days after the operation, having been somewhat delayed because of pain in the knee.

Roentgenograms (Figs. 16-B and 16-C) taken two and a half years after the operation, on March 27, 1944, showed bony union. Function of the leg was completely normal.

CASE 4. L. A. T., male, forty years old, was seen on July 2, 1941. Nine months previously the patient had fractured the neck of the right femur. Conservative treatment was

FIG. 17-A
Case 4. July 2, 1941.

FIG. 17-B
August 31, 1943.

unsuccessful, and the patient was walking with the aid of crutches when first seen. Roentgenogram (Fig. 17-A) showed non-union with marked resorption of the neck. Operation was performed on July 4, 1941. At the same time, a subtrochanteric osteotomy was done, because the writer feels that in cases of non-union of long duration the association of osteotomy and osteosynthesis is useful. After twenty days, plaster was applied down to the knee, leaving the knee free. The cast was left on for thirty days. Walking was begun on the twenty-first day after the operation.

Roentgenogram (Fig. 17-B) made two years after the operation showed union. Walking was normal. A shortening of 2.5 centimeters could be compensated for by the shoe.

FIG. 18-A
Case 5. April 29, 1940.

FIG. 18-B
January 21, 1941.

FIG. 18-C
January 21, 1941.

CASE 5. A. A., male, seventy years old, was seen on April 29, 1940. Eighteen months previously, the patient had fallen from a ladder, and had since been unable to use his left leg. The only treatment was bed rest for two months, and then the patient had begun to walk with two crutches, continuing to use them up to the date of consultation. Roentgenogram (Fig. 18-A) showed pseudarthrosis with extensive resorption of the femoral neck.

Operation was performed on May 3, 1940. Plaster was applied down to the knee twenty days after the operation, and walking was then begun. The plaster was removed after forty days, and walking was continued with a cane. Eight and a half months after the operation, the patient was able to walk two miles easily. Roentgenograms (Figs. 18-B and 18-C) showed that non-union persisted, but the head remained firmly pressed against the trochanter.

FIG. 19-A
Case 6. December 4, 1943.

FIG. 19-B
March 13, 1945.

This shows that, even when bony union does not take place, the osteosynthesis by means of the screw is solid enough in some cases to permit good function, the weight-bearing being supported mainly by the screw.

CASE 6. A. R., male, sixty-one years old, was seen on December 4, 1943. One year and four months previously, the patient had fractured the neck of the right femur. He was treated by traction for forty days, and was walking with two crutches. Roentgenogram (Fig. 19-A) made on December 4, 1943, showed non-union. Operation was performed on December 13, 1943.

Owing to the long duration of the pseudarthrosis, it was decided to perform a subtrochanteric osteotomy at the same time as osteosynthesis. The osteotomy, which immediately followed the osteosynthesis, was intended to increase the circulation of blood, and no attempt was made to displace the distal fragment inward under the weight-bearing line. A short plaster cast was applied, and walking was begun on the twentieth day. The cast remained on for forty days, and then walking with a cane was continued. Roentgenogram (Fig. 19-B), made on March 13, 1945, fifteen months after the operation,

showed complete union. The patient is now working on a farm, and feels no difference in the function of his legs.

CASE 7. F. A., male, sixty years old, was first seen on July 29, 1944. The patient, for many years a diabetic, had fractured the neck of the left femur sixty-nine days previously. He had been treated by traction, and was unable to stand without crutches. Roentgenogram (Fig. 20-A) showed lack of union.

Operation was performed on August 1, 1944. The patient began to walk twenty days afterward in a short plaster spica. Plaster was removed after forty days. The patient is now able to walk perfectly well all day long. Roentgenograms (Figs. 20-B and 20-C), made on March 11, 1945, seven and a half months after the operation, showed union.

FIG. 20-A
Case 7. May 21, 1944.

FIG. 20-B
March 9, 1945.

FIG. 20-C
March 9, 1945.

CASE 8. M. J. S., female, sixty-five years old, was seen on February 26, 1944. Two days previously the patient had suffered a fracture of the neck of the left femur (Fig. 21-A). Operation was performed on February 27, 1944. Four months after the operation, roentgenograms (Figs. 21-B and 21-C) showed perfect union, and walking was normal.

This case is presented to show that, even if the centering of the screw is unsatisfactory, provided impaction is possible, a solid and quick union may be obtained. In the present case, we were forced to accept the first and very imperfect centering of the wire because the patient was not tolerating the anaesthetic well. The screw was placed too far posteriorly distally. Nevertheless a good functional result was obtained.

SUMMARY

1. A series of end results of the treatment with the stud-bolt screw of some particularly unfavorable cases of fracture of the neck of the femur is presented.

FIG. 21-A
Case 8. February 26, 1944.

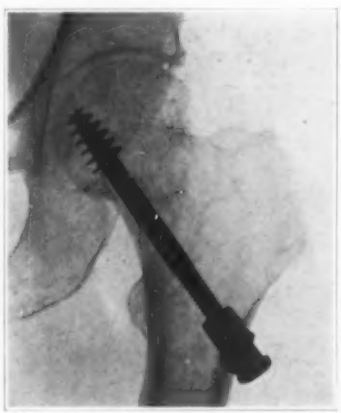

FIG. 21-B
June 20, 1944.

FIG. 21-C
June 20, 1944.

2. The technique and the instruments for the osteosynthesis have been greatly simplified since the author's first description.

3. A hand drill is used instead of the electric motor, and very few special instruments are required, thus making the operation practicable for more surgeons.

4. Eight cases, selected from a series of eighty operations, are reported to demonstrate that, even under particularly unfavorable conditions, union and good function may be obtained with the stud-bolt screw.

5. Two cases of non-union, one of nine and one of sixteen months' duration, are reported, in which union and perfect function have been obtained by the association of osteosynthesis and osteotomy in the same operation.

6. The good results in these difficult cases are attributed to the solidity of the osteosynthesis, and to the strong impaction produced by the stud-bolt screw.

7. A short plaster cast, leaving the knee free, is now usually applied about twenty days after the operation, when the patient begins to walk. This is removed after forty days.

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SELECTION OF CASES FOR ARTHROTOMY OF THE KNEE IN AN OVERSEAS GENERAL HOSPITAL

A Two-Year Follow-up Study

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This report represents a follow-up study of patients operated upon, for internal derangement of the knee joint, who were returned to duty from a General Hospital in the Southwest Pacific Area over a two-year period, from July 1942 to July 1944.

Three means of obtaining accurate follow-up information were available:

First, in order to determine whether any of our patients had been rehospitalized, a follow-up questionnaire, requesting diagnosis, treatment, and disposition, was sent to every General Hospital, Station Hospital, and Evacuation Hospital in the Southwest Pacific Area.

The second means of follow-up was available through the office of the Base Registrar for patients who may have been assigned to limited service duty or to the United States by other hospitals.

The third check was made through the Machine Records Unit, where we obtained information as to the present assignment and organization of each patient.

From these sources the necessary information was obtained on the results of 121 knee arthrotomies out of a total of 124. The remaining three patients were members of the Australian Military Forces, on whom we were unable to obtain complete follow-up information.

SELECTION OF CASES

Early in our overseas experience, we realized the tremendous importance of making a total evaluation of the patient prior to operation. Careful sizing up of the patient as a soldier—his attitude, initiative, and cooperation—had a direct bearing on his postoperative course. An operation may be considered useless from the point of view of the Army when, postoperatively, the patient is discovered to be unfit for duty because of an underlying maladjustment, neuropsychiatric disorder, or for some other mental or physical condition. The other important consideration bearing on the selection of a case for operation was the evaluation of the knee condition, *per se*. Some types of knee derangement carried a favorable prognosis for return to duty, while others did not.

In the latter part of 1942, we adopted a definite policy, the main points of which were:

First, careful selection and evaluation of the patient as a whole;

Second, preoperative and postoperative classification of the patients into two types of cases, those with the "uncomplicated" injuries to the meniscus, and the "complicated" knee cases—those with articular or ligamentous damage, with or without injury to the meniscus;

Third, the institution of a reconditioning course; each patient was required to enter this course after a reasonable time,—usually four or five weeks after operation. Here the patient's course was carefully followed by a medical officer. When the patient had completed his training, he was again evaluated, and then was sent out to the type of duty he was considered capable of performing.

Classifying the patients into "complicated" and "uncomplicated" cases expedited treatment and disposition. The uncomplicated cases were the patients from whom an injured meniscus had been removed, and who demonstrated at the time of the operation an otherwise normal knee joint.

The complicated cases were those in which there were associated changes in the knee joint, in addition to an injured meniscus. These included osteochondritis dissecans, insta-

TABLE I

UNCOMPLICATED MENISCUS CASES

Total number of cases 67. Follow-up complete on 65.

1. Number of patients sent to full military duty 59
   Number of patients remaining at full military duty 50 or 85 per cent.
   Of the nine who did not remain at full duty:
   5 were rehospitalized because of knee complaint.
   3 were returned to the United States
   2 were returned to limited duty.
   1 was returned to the United States because of other medical conditions.
   3 were returned to the United States from their units; these were not rehospitalized, possibly were on rotation or leave.
   Average period of time spent at full duty 10.3 months
   Number of cases remaining at full duty one year and over 24
   Number of cases remaining at full duty less than one year 26
2. Number of patients sent to limited service duty from our Hospital 5
   All remained at limited duty an average of 15 months.
3. Number of patients returned to the United States from our Hospital because of knee complaint 1

   Total number of cases 65
4. Total number of patients returned to the United States from our Hospital and other hospitals because of knee disability 4

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bility of the knee joint as a result of injury to the cruciate or collateral ligaments, hypermobility of the patella, appreciable traumatic arthritis, and severe traumatic synovitis.

After operation the favorable uncomplicated cases were returned to full military duty, of which there were eighteen different types, 49 per cent. of which was infantry field duty. The majority of patients in the group of "complicated cases" were sent to limited duty, or were returned to the United States.

STATISTICAL STUDY

Of the patients admitted to the Hospital because of a knee complaint, 29 per cent. required operation.

The average number of postoperative days spent in the Hospital, including the time in the reconditioning course, was sixty-three.

Of the 121 cases on which the follow-up study was complete, sixty-five or 54 per cent. were regarded as uncomplicated meniscus injuries (Table I). Twenty-three cases or 19 per cent. were classified as complicated meniscus cases (Table II). The remaining thirty-three cases or 27 per cent. were operated upon for reasons other than a torn meniscus.

TABLE II

COMPLICATED MENISCUS CASES

Total number of patients 23. Follow-up complete on 23.

1. Number of patients sent to full military duty 6
   Number remaining at full military duty 2
   4 patients were rehospitalized and were returned to the United States because of knee disability.
2. Number of patients sent to limited service duty 10
   Number remaining at limited service duty 7
   Of the 3 patients who did not remain at limited service duty:
   2 were returned to the United States because of knee disability.
   1 was returned to the United States from his unit, but was not rehospitalized (possibly on rotation or leave).
3. Number of patients returned to the United States from our Hospital 7
   4 because of knee disability
   3 because of other medical conditions

   Total number of cases 23
4. Total number of patients returned to United States from our Hospital and other hospitals because of knee disability 10
5. Average period of time at full military duty 12 months.
   Average period of time at limited service duty 13 months.

TABLE III

CASES OF INTERNAL DERANGEMENT WITHOUT MENISCUS INJURY

Total number of cases 34. Follow-up complete on 33.

1.	Number of patients sent to full military duty	9
	Number remaining at full duty 7	
	The 2 men rehospitalized were returned to the United States because of knee disability.	
2.	Number of patients returned to limited service duty	14
	Number remaining at limited service duty 11	
	2 were returned to the United States because of knee disability	
	1 was returned to the United States from his unit, but was not rehospitalized.	
3.	Number of patients returned to the United States from our Hospital	10
	Total number of cases	33
4.	Total number of patients returned to United States from our Hospital and other hospitals because of knee disability 14	
5.	Average period of time spent at full military duty 11 months.	
	Average period of time at limited service duty 15 months.	

These figures show that the patient with an uncomplicated injury to the meniscus can be expected to perform full military duty, if a careful operation is done, and if the postoperative care is rationally carried out.

The men classified as complicated knee cases, on the other hand, will not be serviceable in duties which require excessive use of the knee. Selected patients may make useful soldiers at limited duty, and a few may return to full duty, but they must be equipped to do a specialized type of work. Approximately 43 per cent. of the complicated knee cases were found unfit for any type of duty in a theater of operations, and were returned to the United States. Particularly poor results in this group were found in the cases of moderately severe to severe osteochondritis, and in the knee unstable because of damage to the cruciate ligament. The knees with moderately severe traumatic changes, and without loose-body formation in the joint, responded better after the injured meniscus had been removed.

In the Army Medical Bulletin, May 1944[1], elective surgery of the knee joint was discussed, and the causes for poor results were outlined. Our experience concurs with the opinions expressed therein.

The following are some of the significant facts as to the history, physical findings, and roentgenographic studies in our series of cases.

History

Of the cases in which a torn or injured meniscus was found at operation:

The mechanism of injury was a twist of the knee joint in 98 per cent. of the cases.

A history of locking was elicited in 70 per cent. of the cases, swelling of the joint in 95 per cent., and pain at the time of injury in 97 per cent. We found that it was most important to have the patient describe exactly what took place when his knee "locke[d]."

The number of attacks was significant, and helped to determine whether or not o[pera]tion should be performed. It can be said, however, that once a meniscus is split lon[gi]tudinally, it never heals, and recurrent attacks should be expected.

Physical Examination

The most consistent physical findings in the cases in which a torn meniscus was found at operation were:

Atrophy of the quadriceps muscles in 68 per cent. of the cases;

Localized tenderness and abnormal prominence of the meniscus at the joint line in 88 per cent.;

Excess joint fluid in 50 per cent.;

Limitation of motion, particularly in extension, in 63 per cent.

Roentgenographic Examination

Anteroposterior and lateral roentgenograms were taken of all patients. Except for the demonstration of calcified loose bodies and traumatic changes of the articular surfaces,

the evidence of derangement was of a negative nature. We have not in any case used pneumarthrograms as a diagnostic procedure. We do not believe they are necessary, and fear that they may at times be misleading.

Findings at Operation

Of the eighty-eight cases in which the meniscus was injured, seventy-seven or 87 per cent. were of the medial meniscus. Of these seventy-seven cases, the "bucket-handle" type of tear was found in 70 per cent.; in 25 per cent. there were multiple tears; and in 5 per cent., transverse splits. There were eleven cases or 12 per cent. in which the lateral meniscus was injured; seven of these were associated with cystic degeneration of the lateral meniscus. The posterior third of the meniscus was injured in twelve of the above cases: eleven of the medial meniscus, and one of the lateral meniscus. Herniation of the joint capsule in the popliteal region was associated with injury of the medial meniscus in two patients.

Other findings in the series of 121 cases were:

a. Osteochondritis dissecans of the femoral condyles in fifteen patients; in twelve of these, cartilaginous or ossified bodies were present. The lesion was on the medial femoral condyle in eleven cases, usually on the lateral aspect, and on the lateral femoral condyle in four patients.

b. Chondromalacia of the patella was present in eleven patients. In nine of these there was no associated injury to the meniscus.

c. Giant-cell tumor of the knee-joint capsule was found in two patients.

d. Calcification of the split posterior third of the medial meniscus was present in one patient, and ossification in another.

e. Intra-articular ganglia of the patella and quadriceps tendons were present in one patient.

f. An anatomical variation, consisting of a congenital veil or membranous septum, dividing the knee completely in the anteroposterior plane, was present in one patient.

Six of the 121 patients had been previously operated upon in other hospitals. On all of these further exploration was done, and in all we found tears or partial detachment of an incompletely removed posterior portion of the medial meniscus. After operation all of these patients were returned to duty.

In five of the 121 arthrotomies, the findings were within normal limits. Two of these presented so-called "hypermobile menisci"; they were removed, but we did not feel certain that they were the causes of internal derangement. All were sent to duty, four to full military duty, and one to limited service duty, where they remained. It is significant that in only one of this group was there a history of "locking" of the knee.

Postoperative Complications in 121 Cases

a. Postoperative sepsis—one case. This occurred during a period when many septic battle casualties were being received. After drainage and Kirschner-wire traction, the patient had gained flexion of 50 degrees, and complete extension at the time of evacuation.

b. Temporary sciatic nerve palsy—four cases. This occurred because the tourniquet was placed too close to the ischial tuberosity, where the sciatic nerve is relatively unprotected. All recovered completely in a few weeks.

c. Thrombophlebitis—one case. This subsided, and did not interfere with patient's return to full duty.

OPERATIVE TECHNIQUE

Prior to operation, careful instruction in quadriceps-setting exercises is given to the patient. Forty-eight hours prior to operation a graphic temperature chart is begun, and throat culture is taken for hemolytic streptococcus. With a temperature of over 99 degrees, or when more than an occasional streptococcus is present in the throat culture, the operation is cancelled. The skin is prepared forty-eight hours and again twenty-four hours before the operation.

A thigh tourniquet, placed about four inches below the level of the ischial tuberosity, is used in all cases. This consists of a soft rubber tube, one-half inch in diameter, applied twice around the thigh over a Turkish towel.

Incision: When we are reasonably certain that the patient has an uncomplicated meniscus injury we use the "combined" incision[2], which begins three-eighths of an inch posterior to the femoral epicondyle, and curves downward and forward to the joint line and to the mid-portion of the patellar tendon. On the inner aspect of the knee, the patellar branches of the internal saphenous nerve are identified, and retracted. The anterior compartment is opened with a curved incision, in front of the collateral ligament; this allows adequate inspection of the anterior joint space. A second capsular incision, perpendicular to the joint line, is made posterior to the tibial or fibular collateral ligament, as the case may be, and the posterior joint space is exposed. The anterior portion of the meniscus is dissected free through the anterior incision, and passed backward between the collateral ligament and the joint space and removed through the posterior incision. With cases in which a more adequate exposure of the joint is desired, or when the diagnosis is not reasonably definite, the knee is opened by a parapatellar incision three or four inches in length (7.5 to 10 centimeters), and, if necessary, it is enlarged superiorly or inferiorly. Careful inspection of the knee joint is carried out routinely, including the opposite meniscus, the articular surfaces of the femur, tibia, and patella, the cruciate ligaments, the synovial membrane, and the infrapatellar fat pad. No. 60 cotton is used for ligatures, and No. 40 cotton for sutures.

Following closure of the joint, a soft compression dressing is applied, and the leg is bandaged with a stockinette roll or an elastic bandage from toes to groin. The tourniquet is then removed. This type of complete bandage may help to prevent postoperative phlebitis. The leg is supported by a pillow. Traction is never used. On the first postoperative day, quadriceps-setting exercises are begun. The patient is not allowed up until he can actively raise his leg with the knee straight. He is then required to use crutches until he has demonstrated a correct gait. For physiotherapy he is given graduated exercises, followed by bicycle-riding, rope-jumping, and exercises on a rowing machine. From the physiotherapy clinic the patient is sent to the reconditioning area.

CONCLUSIONS

1. In order to prognosticate which patients with internal derangement of the knee will return to full duty after operation, careful preoperative evaluation of the patient as a whole is essential. This involves the sizing up of the individual from the psychological standpoint; the taking of a detailed history as to the mechanism of injury; a systematic and thorough physical examination including: inspection, palpation, motions, stability, stance, and examination of the joints above and below the knee. The opposite or normal knee should always be examined for comparison.

2. Usually the patients can be classified into two groups: (1) those having uncomplicated injuries to the meniscus, and (2) those with damage to the articular surfaces or ligaments, which may or may not be associated with injury to the meniscus.

3. The vast majority of patients with an uncomplicated meniscus injury can be returned to, and will remain at, full military duty, if a careful operation is carried out, and if the patient is reconditioned prior to his discharge from the hospital.

4. Patients whose knee disability is due to, or complicated by, articular damage or instability of the joint should not be operated upon in an overseas theater, unless symptoms are sufficient to cause severe pain or locking of the joint.

5. Exceptions to the previous statement may be made in so-called "key personnel" who, after operation, can return to limited service, not requiring excessive use of the knee.

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ANTERIOR TRANSPOSITION OF THE PERONEAL NERVE FOR TRACTION PARALYSIS

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Peroneal palsy is, fortunately, among the more unusual of the complications associated with fractures about the knee. Its occurrence appears to have been attributed principally to direct contusions or to pressure against the nerve. The degree of this pressure need not be excessive, and, in the opinion of Selig, may result from the improper application of adhesive plaster to the leg, even in the absence of fracture.

Platt [5] first called attention to the fact that this nerve may exhibit paralytic phenomena as a result of clinical conditions associated with excessive traction. These may include instances arising as a consequence of accident or trauma incidental to the operative correction of genu valgum. In his first communication in 1928, Platt especially emphasized his belief that the nerve lesion is a concomitant of fractures of the styloid process, as contrasted with fractures of the neck of the fibula, although it is expressly stated that "the external popliteal nerve lesion which accompanies separation of the fibular styloid, is a true primary injury which bears no *casual* relation to the treatment of the fracture".

In 1931, Watson-Jones, apparently unaware of Platt's earlier observation, reported a case which he believed to be unique. This concerned a man of fifty-six who had been knocked down by a motor car, and suffered an avulsion of the styloid process of the fibula, with incomplete paralysis of the external popliteal nerve (common peroneal). During operation to reduce the fracture, the peroneal nerve was "found not to have been ruptured, although recent hemorrhage into the sheath was evident. The styloid fragment was replaced and sutured with braided silk, and ten weeks later, when the plaster was removed, the paralysis had completely disappeared."

Watson-Jones noted that: "Three features of interest are presented in this case. Although crack fractures of the upper end of the fibula are not uncommon, complete avulsion with wide separation is rare. . . . Secondly, complete recovery of peroneal palsy is unusual; but as a rule the nerve is injured by contusion, whereas in this case the block has been purely 'physiological' and it is attributable to momentary stretching of the nerve trunk. Finally, the close resemblance between the clinical syndromes in knee and elbow is remarkable. In each condition, in consequence of a lateral strain there is subluxation of the joint, avulsion of capsule, and aponeurosis with an attached fragment of bone, displacement of the fragment into the joint, and coincident traction injury of the nerve."

In 1940 Platt [6] elaborated the clinical picture, and described the palsy as an intrinsic part of the "ligamentous-peroneal syndrome characteristic of adduction injuries of the knee joint". As its hyphenated designation indicates, the syndrome is a combination form, defined (a) by the presence of peroneal paralysis, and (b) by a triad of signs characteristic of adduction injuries to the knee joint,—rupture of the lateral capsule, avulsion of the styloid process of the fibula, and avulsion of the biceps tendon from the fibular attachment.

Although the validity of each of these syndromes may be accepted, it is very questionable whether or not the combination may properly be considered as a true syndrome. Experience would seem to indicate that severe damage to the ligamentous apparatus of the knee occurs more frequently alone than in combination with injuries to the peroneal nerve. Even an avulsion fracture of the fibular styloid may occur without peroneal palsy[4]. On the other hand, paralysis in the distribution of this nerve may and does occur without injury to the ligamentous apparatus or fracture of the styloid process of the fibula. While

either one of these two syndromes may arise as a result of the forces of excessive traction, the association of the two does not appear to be consequential, as will be seen in the following cases.

CASE REPORTS

CASE 1. Anna P., forty-one years old, was seen on January 26, 1943, about seven weeks after an automobile injury. On December 8, 1942, the patient had been thrown against the dashboard of her automobile, and had suffered a severely comminuted fracture of the upper end of the right tibia. The leg was promptly immobilized in a Thomas splint, and roentgenograms, taken upon her admission to another hospital, showed excellent alignment of the fractured fragments. Unfortunately, the splint was removed, and a plaster-of-Paris cast was applied, with the knee in complete extension. Ten days later the patient was discharged from the hospital, but on January 18, 1943, she returned to the hospital because the plaster had become loose. New roentgenograms showed unsatisfactory position. The lower fragment was hyperextended, and there was definite backward angulation at the level of the fracture. The distal tibial fragment and the fibula had been displaced proximally, and the tibial plateau was increased in diameter. A new plaster was applied, but shortly thereafter the patient began to complain of a tingling in the toes.

Examination disclosed a moderate increase in the diameter of the right knee. This was clearly caused by the projection of the fibular head beyond the lateral surface of the tibial condyle. Flexion of the knee was possible to 90 degrees, extension to 170 degrees. No lateral instability of the knee joint could be elicited. Due to posterior angulation of about 15 degrees, the leg presented the appearance of a true genu recurvatum. No false point of motion could be clinically demonstrated, and there was no evidence of peroneal palsy.

Roentgenogram (Fig. 1-A) taken on January 26, 1943, showed a comminuted intra-articular fracture of the proximal end of the tibia. The distal fragment showed posterior displacement of one centimeter. Early callus formation was present. Though its significance was not specifically appreciated until later, attention should be called to the fact that there was a displacement of the fibular head, with an increase in the transverse diameter of the upper end of the tibia. By comparison with the bicondylar diameter of the upper end of the femur, it could be observed that the distance of the fibula from the tibial shaft was definitely greater than normal. Fracture of the fibula or its styloid process was not seen.

In the hope that some of the deformity could be overcome, skin traction, using four pounds of weight, was applied. The following day the patient began again to complain of pain in the leg. Two days later, complete dropping of the foot and a loss in the power of the peroneal muscles were noted. There was hypaesthesia to pin prick in the peroneal-nerve distribution; and pressure over the nerve, as it wound around the fibula, elicited tenderness. Roentgenograms showed no essential change in position. Since the palsy appeared so promptly following the application of skin traction, it seemed to be the direct cause of the nerve symptoms. Because of the excessive extension of the distal fragment, it was believed that the skin traction had resulted in a hyperextension type of peroneal palsy. Although all traction was promptly discontinued, there was no abatement of symptoms.

Neurological consultation confirmed the presence of the nerve lesion. Surgical exploration was cautioned against, and conservative therapy was advised. Heat, massage, and electrotherapy were carried out over a period of two weeks, but without any sign of improvement. It was felt that the lack of any response to therapy indicated the continuing action of a force other than the skin traction. Study of the roentgenograms gradually gave rise to the conclusion that this force came from the tension caused by an increase in the tibiofibular distance. It was determined to explore the nerve with this in mind.

Under general anaesthesia on February 18, 1943, an incision, four inches (ten centimeters) long, was made over the lateral aspect of the leg, exposing the peroneal nerve. The nerve was found to be completely intact, but over the head of the fibula it was reddened, markedly flattened, and quite obviously under considerable tension. This was clearly due to the resistance offered by the fibular attachment of the deep fascia, which actually snapped as it was cut across to release the nerve. The nerve was then translocated forward. Although the nerve tension was considerably reduced, it was not completely relieved. In its normal position the fibular head presented a bony resistance to the nerve, and it was felt that the tension on the nerve could be overcome only by resecting the head so as to reduce the distance to be traversed by the nerve. The collateral ligament and the biceps tendon were thereupon dissected away, and the fibular head was excised (Fig. 1-B). The nerve could then be dropped loosely into the hiatus thus created. The biceps tendon and the collateral ligament were sutured to the tibia, and the wound was closed. The postoperative convalescence was uneventful, and the wound healed by primary intention.

Two days after the operation, the patient noted a return of sensation along the inner and outer borders of the foot. Slight power in the anterior tibial and the peroneal muscle began to reappear. On the fifth day, sensation was fairly normal, and there was obvious restoration of power in the foot, although the extensors were still quite weak. On March 6, the patient was permitted to begin weight-bearing, with the aid of crutches, and her discharge from the hospital was recommended. Upon her

FIG. 1-A

Case 1. Comminuted fracture with increased tibiofibular distance due to the increase in the width of the tibial condyles.

FIG. 1-B

Same as Fig. 1-A, after resection of the fibular head to accommodate the peroneal nerve.

FIG. 2

Case 2. Avulsion fracture of the fibular head. The comminuted styloid process has been pulled up to the level of the knee joint.

return home she was given electrotherapy and gentle massage. There was slow but progressive return of function. By the middle of July the patient was walking normally, without any aid or support. The power in the foot muscles was normal, but some limitation in complete flexion of the knee persisted, and on extension the recurvatum deformity was still noted. Apart from this, the patient disclaimed any disability, and she has since resumed her normal activities.

The preoperative clinical picture and the appearance of the nerve at operation are readily explained on the basis of excessive traction. It must be presumed that the mushrooming of the upper end of the tibia, and the subsequent outward and upward displacement of the fibular head resulted in an increase in the distance from the fibular neck to the point of distribution of the peroneal nerve, in the muscles of the anterior and lateral compartments of the leg. Because of the fixation of the nerve as it curves around the fibular neck, any increase in the tibiofibular distance necessarily imposes a traction force on the portion of the nerve distal to the point of fibular fixation. That so slight an increase in tension as might be occasioned by mild flexion of the thigh (with knees extended) could give symptoms of tingling, indicated the slight margin of tension beyond which injury to the nerve supervened. It may readily be conceived that the effect of continuous traction was such as to lead to motor as well as to sensory disturbances.

The failure to respond to conservative treatment, and the relatively rapid response following removal of the bony obstruction, represented by the fibular head, clearly lend support to Platt's conception, and justify his recommendation that all cases of peroneal traction palsy merit early exploration. The fact that this condition arose seven weeks after injury, in the absence of fracture of the fibula, and as a result of a mechanism which usually does not produce lesions of the ligaments of the knee, serves to indicate the separate nature of the ligamentous and the peroneal syndromes. This is further emphasized by the fact that fractures of the fibular head need not necessarily be associated with peroneal palsy, as the following case illustrates.

Case 2. Abraham S., seventy-five years old, was struck across both knees by a falling bale of hay. The patient was immediately incapacitated, and roentgenograms revealed fractures of both legs. There was a comminuted depressed fracture of the articular surface of the head of the left tibia. On the right side there was a comminuted fracture of the head of the fibula. A triangular fragment of bone, measuring seven-eighths by one-half of an inch (2.2 by 1.2 centimeters), and a smaller linear fragment had been broken off; they had become displaced and rotated cephalad. The head of the fibula was dislocated slightly externally and anteriorly from its normal position (Fig. 2).

The fracture of the left leg appeared to be of the type seen in "bumper" fractures; that of the right leg resembled the fracture described by Watson-Jones, and seemed to belong more in the category of the hyperadduction injuries described by Platt.

Although there was no evidence of peroneal palsy, the case seemed to fall so completely into the category described by Platt that exploration of the area seemed justified. Under local anaesthesia, a three-inch (7.5 centimeters) longitudinal incision was made, and the fascia was incised. A somewhat tense peroneal nerve was found, lying in the depression between the fractured portions of the fibula. The upper end of the peroneus longus and the fascia remaining attached to the fibular head were severed, so that the nerve could be easily translocated forward. This resulted in a relative increase in the length of the nerve, and, therefore, a complete disappearance of the tension. Because of the patient's age and general condition, the bony fragment was anchored in position without extensive efforts being made for anatomical reposition. The muscle was thereupon sutured back into position, and the fascia was reunited over the nerve. A straight-leg plaster was applied for a period of three weeks, and thereafter active motion was gradually begun. Despite the fact that the avulsed fragment was never replaced, the patient at no time gave evidence of either motor or sensory disturbance in the distribution of the peroneal nerve.

It is, of course, impossible to assert that the slight degree of tension noted in this case would have been sufficient to cause an ultimate traction palsy. It is consequently impossible to maintain that the treatment undertaken was justified by the outcome. The absence of true paralysis may be due to the fact that the nerve lay in the depression between the two fractured fragments of the fibula. In this way, a compensating increase in length of the nerve had been achieved, and the possible paralyzing effect of excessive traction had been avoided.

FIG. 3

Anatomical specimen. The fascia has been reflected to show the two heads of the peroneus longus. The peroneal nerve is seen crossing the lateral aspect of the fibula, and curving medially in the groove between the tibial and fibular origins of the peroneus longus.

DISCUSSION

The importance of traction in the etiology of nerve lesions has been studied by Highet and Holmes[1], who made a report on a series of eight cases in which in general they agreed with the observations of Platt. However, in four of their cases, in which extensive resection and nerve suture were performed, failure resulted. In commenting upon this they state: "This failure is understandable in those cases in which the nerve was completely divided, as it was due to the inability of the regenerating fibres satisfactorily to bridge the gap between the stumps. But in those cases in which the nerve-trunk retained a considerable degree of continuity, the absence of recovery cannot be accounted for so simply. It cannot have been due to damage to the central neurons or to failure of the axons to regenerate through the lesion, for in all cases in which there was some continuity of the nerve, very many non-myelinated axons were found to have grown out to its distal end. The most significant observation is that these axons had failed to increase to a normal diameter, and most of them had failed to become myelinated." It was the belief of these writers that this failure was due to tension itself. In a later paper [2] Highet and Saunders showed experimentally that extensive changes, including degeneration of the central portion, rupture of the neurolemma, oedema, and extensive fibrosis in and about the nerve were the results of stretching.

From the fact that release of the peroneal nerve in Case 1 resulted in prompt subsidence of paralytic phenomena, it seemed reasonable to review the anatomy of the peroneal nerve in the region of the fibular head. Usually the peroneal nerve is described casually as coursing down behind the head of the fibula, until it reaches the neck around which it winds. This does not appear to be entirely accurate. Examination of the anatomical specimen (Fig. 3) will reveal that the nerve runs along the posterior border of the biceps. It then courses obliquely downward, forward, and medialward along the lateral aspect of the upper end of the fibula between the two heads of the peroneus longus, until it reaches the level of the fibular neck. The relationship of the nerve to the origin of the peroneus longus is of the utmost importance, and is described by Wood Jones in the following manner: "The tibial origin is from a small area on the upper extremity of the bone immedi-

ately in front of the articular facet of the superior tibio-fibular joint, and with some of the fibres of the anterior ligament of this joint additional bonds of origin are made. On the fibula it arises from the anterior and lateral aspect of the head and from the upper two-thirds or so of the lateral surface of the shaft." These two origins "are separated by an interval (which may be likened to the musculo-spiral groove on the humerus) in which the lateral popliteal (peroneal) nerve lies and give origin to its musculo-cutaneous (superficial peroneal) branch".

As the peroneal nerve winds around the neck of the fibula, it makes an almost right-angled turn around the tibial head of the peroneus longus. But even more important than this is its relationship to the fascia lata which lies superficial to the peroneus longus muscle, and takes a firm attachment to the fibular head at a point just above and slightly more lateral to the origin of the long head of the peroneus longus. Both the muscle and the fascial attachment act as a fulcrum around which the nerve changes its course. Since the nerve is covered by the deep fascia, this knee-like change in direction acts as a fixed point against which traction may be exerted.

In view of the analogy which Watson-Jones noted between the valgus strain of the ulnar nerve at the elbow, and the varus strain of the peroneal nerve at the knee, it was only natural to attempt, at the knee, the sort of nerve transplantation which Platt performed at the elbow. This can be easily accomplished by making an incision over the upper end of the fibula. The biceps is identified, and the peroneal nerve is isolated at a level above the styloid process of the fibula. By following the nerve downward, the intermuscular space is easily defined, and the fascia and the medial head of the peroneus longus muscle are detached. When this has been done, the peroneal nerve can be transposed medially so that it winds around the lateral to the anterior aspect of the biceps tendon. By descending directly to its distribution in the muscles of the anterior compartment of the leg medial to the superior tibiofibular joint, the right-angled bend of the nerve is eliminated (Fig. 4). A relative increase in the length of the peroneal nerve, sufficient to provide for excessive traction due to increase in the tibiofibular distance, can be

FIG. 4

Anatomical specimen. The fascia and the tibial origin of the peroneus longus have been detached from the fibular head. As compared with Fig. 3, the peroneal nerve can be seen displaced forward out of its groove. Crossing the biceps, it lies medial to the fibular head, and ascends directly to the muscle, instead of following a right-angled course around the lateral origin of the peroneus longus.

accomplished. Where it is felt that simple transposition will be insufficient, excessive traction on the nerve can be obviated by resection of the fibular head as in Case 1.

SUMMARY

Excessive traction on the peroneal nerve, with resulting paralysis, may be removed by the operation of anterior transposition of the nerve, after the tibial head of the peroneus longus muscle has been detached. In those cases in which simple transposition is insufficient, resection of the fibular head offers a means of overcoming relative disproportion between the nerve and the tibiofibular distance.

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ACUTE ISCHAEMIA OF THE ANTERIOR TIBIAL MUSCLE AND THE LONG EXTENSOR MUSCLES OF THE TOES

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Recently a peculiar type of vascular disturbance, localized to the anterior fascial compartment of the leg, has been observed in young and otherwise healthy soldiers. No acute trauma has been associated with the onset of such disturbance. The following conditions have been considered and eliminated in the differential diagnosis: emboli, aneurysm, Raynaud's disease, thrombo-angiitis obliterans, arteriosclerosis, periarteritis nodosa, peritendinitis crepitans, phlebitis, cellulitis, fibrositis, rheumatoid arthritis, anterior poliomyelitis, myositis due to bacteria or parasites, and tumors of the muscle. The characteristic clinical symptoms and findings are as follows:

1. Sudden onset of severe pain in the anterior portion of the leg;
2. Rapid development of swelling that is most marked over the anterior fascial compartment;
3. Mild to intense erythema and glossiness over the anterior fascial compartment;
4. Slight to complete interruption of function of the common peroneal nerve.

The clinical course is illustrated by the following case reports.

CASE 1. A white soldier, aged twenty-three, was admitted to the Section of Septic Surgery, complaining of pain in the anterior aspect of the right leg, which had begun during a twenty-mile march on the previous day. There was an intense erythema over the anterior fascial compartment of the right leg. There was marked swelling of the leg, and a complete peroneal palsy. Temperature was 98.6, pulse was 74 and regular. The blood count, including differential, serology, and urinalysis were normal.

Incision of the anterior fascia cruris was done six days later. The anterior tibial muscle bulged out of its fascial compartment, as though it were under considerable pressure. The muscle was gray and avascular when first exposed, but it appeared to regain some circulation while under observation. A photomicrograph of a section of this muscle is shown in Figure 2. The incision could not be closed due to marked retraction of the skin edges. Healthy granulations developed over the muscle, allowing application of pinch grafts. Complete epithelization of the wound took place. However, there was no return of function to the ankle and toe extensors or to the peroneal muscles, and a permanent foot-drop resulted.

CASE 2. A white soldier, aged twenty-six, of Anglo-Saxon descent, was admitted to the Section of Septic Surgery, complaining of pain and swelling of the right leg. The family history was irrelevant. He smoked from twenty to thirty cigarettes daily, and drank about one quart of whiskey per week. The only injury had been a sprain of the right ankle in childhood. For several months he had noted pains in both legs during forced marching. He had experienced a sudden sharp throbbing pain in the anterior part of the right leg, while walking the previous evening.

Physical examination was essentially normal, except for the right leg. The temperature was 98.6, pulse 78 per minute and regular; blood pressure 120/70. Laboratory findings were as follows:

Red Blood Cells, 5,300,000
Hemoglobin 100 per cent.
White Blood Cells, 12,950

Polymorphonuclear neutrophils	74
Lymphocytes	20
Monocytes	6

Reaction to the Kahn test was negative; the sedimentation rate was six millimeters for the first hour; urinalysis showed nothing significant.

The patient was first seen by the orthopaedic consultant two days after admission. Marked swelling and moderate erythema of the anterior surface of the right leg were apparent. There was a complete right peroneal palsy. The pulsation of the right dorsalis pedis was faintly palpable, but the pulsation of the right posterior tibial artery was very full and strong. Treatment was instituted by infiltrating the right first, second, and third lumbar sympathetic ganglia with a solution of 1 per cent. procaine. A definite warming of the leg was produced within a few minutes. The sympathetic block was repeated, and a spinal anaesthetic of 100 milligrams of procaine was given three hours later, with a satisfactory warm-

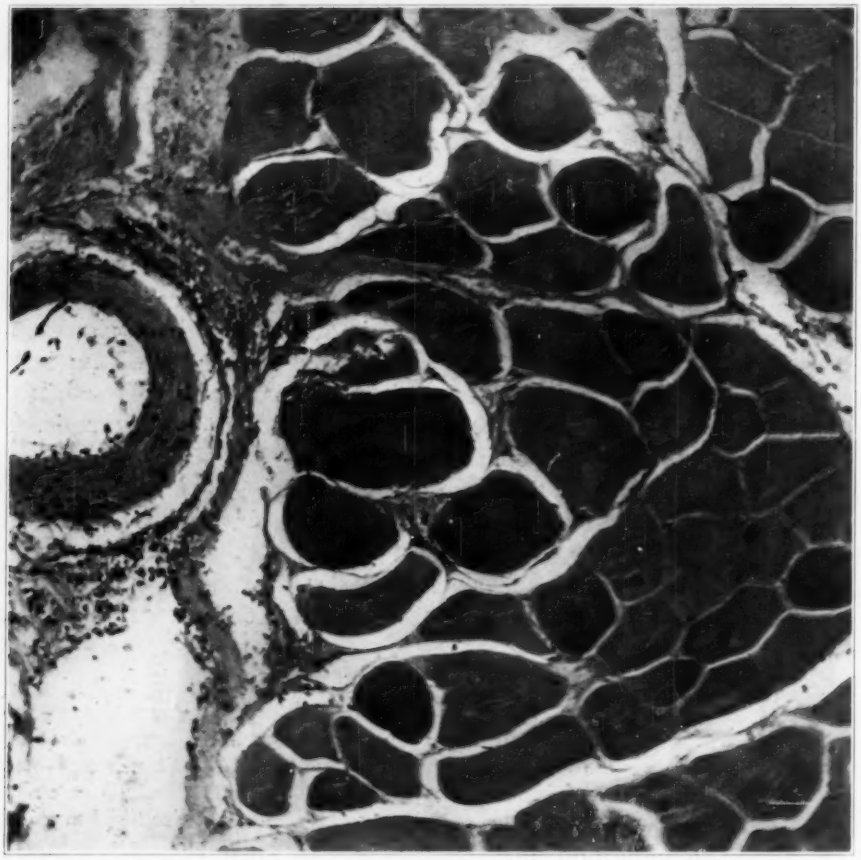

FIG. 1

Photomicrograph (× 120) of anterior tibial muscle three days after onset of symptoms. Section stained with hematoxylin and eosin.

ing of the entire right leg. A definite dorsiflexion of the right second and fifth toes was observed six hours after the second sympathetic block. However, the right anterior tibial muscle could be easily palpated as a stony hard mass. At operation a complete vertical incision was made through the anterior fascia cruris. The muscle immediately bulged anteriorly, exposing a gray, oedematous belly. Patches of muscle about two to three centimeters in diameter and of a port-wine color were observed. About 50 per cent. of the muscle was débrided until retractile and bleeding portions were encountered. The bleeding was not normal, but it was hoped that with the release of the fascia some collateral circulation would be established. A culture of the muscle showed no growth. A photomicrograph of this muscle is shown in Figure 1. The patient remained essentially afebrile, but a foul odor developed about the right leg. He was again operated upon thirteen days following the first operation. The entire anterior tibial and extensor hallucis longus muscles were found to be gangrenous, and were removed by finger dissection. The anterior tibial artery was found to be pulsating normally at the level of the opening in the interosseous membrane, but this pulsation rapidly diminished, so that it could not be felt two centimeters distally. A gray firm mass, 2.5 centimeters in diameter and one centimeter thick, was found encircling the anterior tibial vessels eight centimeters from the inferior edge of the opening of the interosseous membrane. A segment of the anterior tibial artery and vein, fifteen centimeters in length, and including the mass, was excised between ligatures. No oedema or color changes on shifting of position developed in the foot. Complete healing of the wound took place. There was return of excellent function to the peroneal muscles and short extensors of the toes. The patient was able to walk quite well with a light spring drop-foot brace. All studies of the cardiovascular system have been negative, except for the lesions of the anterior tibial vessels.

PATHOLOGY

The microscopic picture of the affected muscles is shown in two stages early in the disease. Figure 1 is a high-power photomicrograph of a section of muscle made three days after the onset of symptoms, revealing a marked enlargement, swelling, and intra-

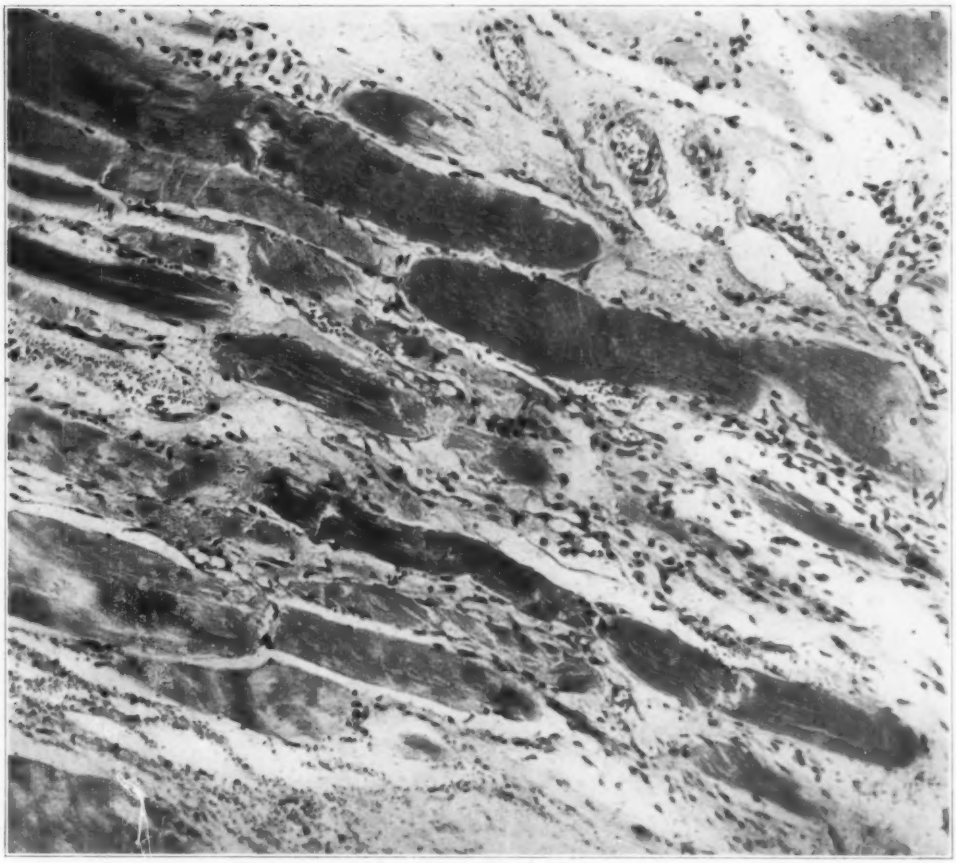

FIG. 2

Photomicrograph (× 120) of anterior tibial muscle six days after onset of symptoms. Section stained with hematoxylin and eosin.

fibrillary oedema of the muscle cells. The muscle cells have lost their striations, and some of them are undergoing necrosis. There is an exudate of serum in some cells between the muscle fibers. The blood vessel shows the same type of degenerative process that is found in the muscle cells. There seems to be an increase in fibrosis about the vessel, and there is a fresh exudate of polymorphonuclear leukocytes and round cells in the adventitia of the vessel and in the surrounding fibrous tissue. There is also a moderate cellular exudate in the media of the vessel.

Figure 2 is a high-power photomicrograph of a section of muscle six days after the onset of symptoms, showing fragmented pieces of muscle fibers undergoing various degrees of degeneration. Some of these are enlarged and oedematous. Others are necrotic, and are being absorbed by an infiltrate composed of round cells, macrophages, atypical giant cells, and fibrous tissue. All of the muscle cells have lost their striations. Many of the capillaries between the muscle fibers are greatly dilated, probably because of the loss of a supporting wall formed by the muscle fibers.

In short, the section shows degeneration and necrosis of muscle, and replacement of this process by young fibrous tissue, macrophages, round cells, and giant cells. These pathological changes took place within six days after the onset of symptoms. The end result of this pathological process would be complete replacement by dense fibrous tissue of the degenerated and necrotic muscle cells. In other parts, where large areas of the muscle may be involved, the process of absorption of necrotic tissue and replacement by fibrous tissue may not be great enough to cope with the large areas of necrosis, and a necrotic sequestrum of muscle may result, as described by Bristow and by Griffiths.

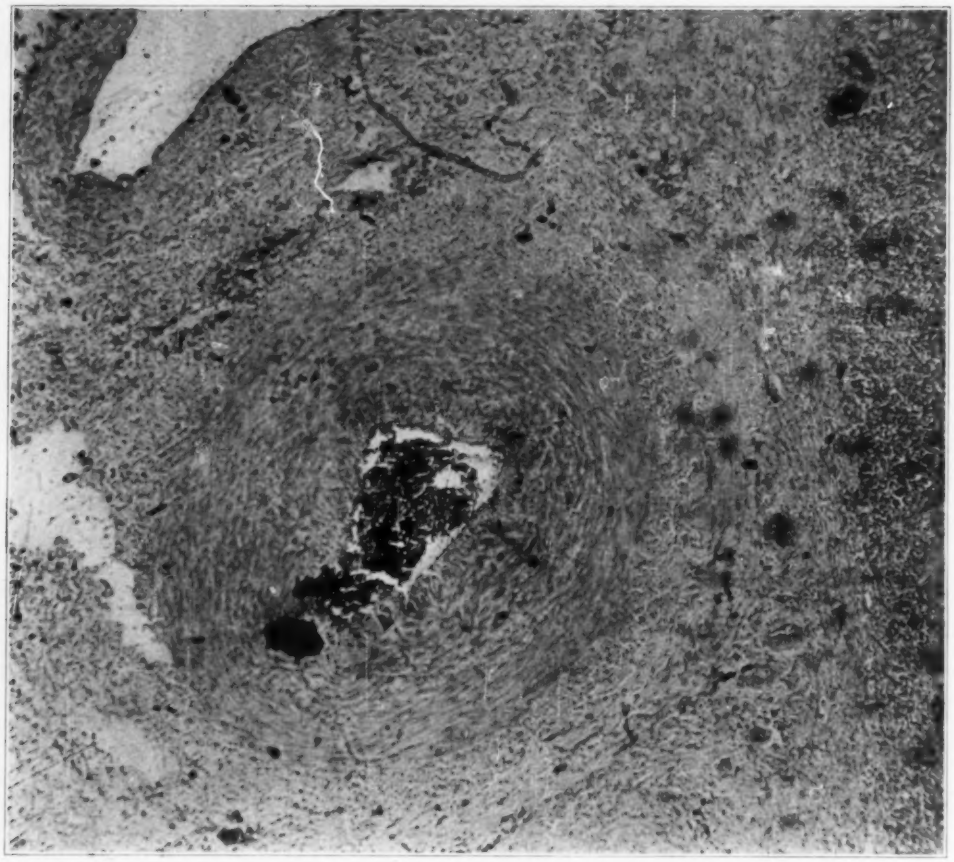

FIG. 3

Photomicrograph (× 44) of anterior tibial artery and portion of the anterior tibial vein sixteen days following onset of acute symptoms. Section stained with hematoxylin and eosin.

The microscopic picture of the vessels involved in the ischaemia of the anterior tibial muscle and long extensors of the toes is shown in Figure 3. This low-power photomicrograph of the anterior tibial artery reveals a marked thickening of all the layers of the artery. The lumen is narrowed. The intima is thickened, and there is reduplication of the internal elastic membrane. The muscularis is hypertrophied, somewhat fibrotic, and contains an occasional round cell. The adventitia is greatly thickened, and also has round-cell infiltration. The periarterial tissues are markedly fibrotic, and densely infiltrated with a cellular exudate, consisting of round cells, plasma cells, and polymorphonuclear leukocytes. The adjoining vein is also involved in this pathological process. The marked fibrosis of the adventitia and of the periarterial tissues is obviously of long standing, and antedates the changes in the muscle shown in Figure 1, which was taken from the same patient.

Pathogenesis

The cause of the fibrosis of the media, adventitia, and periarterial tissue of the anterior tibial artery is subject to conjecture. Chronic trauma has been advanced as the cause of arterial lesions by Learmonth, Blackwood, and Richards. They described four cases of localized arterial thrombosis of undetermined origin. The brachial artery was thrombosed in one patient, and the femoral artery in three patients. They demonstrated the histological sections of the arteries in two cases, which revealed some similarities to the section presented here. They concluded, by exclusion, that trauma was the causative

agent. Lowenberg affirmed that the use of a chipping hammer, and the operation of a stiff foot pedal on a tractor were factors in the production of arterial thrombosis.

Vogt observed soldiers suffering from ischaemia of the anterior tibial muscle, and concluded that continued sliding contact between the anterior tibial vessels and the edge of the aperture in the interosseous membrane produced an irritation leading to vasospasm and resultant ischaemia. This theory is not substantiated by our operative findings in Case 2.

Sirbu, Murphy, and White described ischaemia of the anterior tibial muscle in two soldiers. In one soldier, the ischaemia developed following repair of a hernia of a small muscle, and in the other soldier, ischaemia of the anterior tibial muscle of both legs followed as a result of marching. These writers believe that there is a direct relationship between excessive marching and circulatory disturbances in the anterior tibial muscle.

Howard has studied the chemical and histological changes in the muscle of patients having peritendinitis crepitans. This condition develops when individuals perform certain repeated, rapid motions to which they are unaccustomed, or when they continue to use a muscle that has suffered a direct trauma.

The primary pathological change is exhaustion of the muscle, with retention of lactic acid, and a depletion of muscle glycogen. Histologically the venules are thrombosed; all tissues are oedematous; hemorrhage is present in areolar tissue and muscle; and fibrin is deposited about the peritenon in clumps. The muscle fibers have lost their cross striations, and they may be hyalinized in mild cases, or they may be frankly necrotic in severe cases.

Howard believes that all of these changes arise from fatigue and muscle exhaustion, and not from bacterial infection or so-called toxic conditions. His excellent work may explain the onset of severe ischaemia in soldiers after marching. The continued motion of picking up the foot while marching is accomplished by the anterior tibial muscle and long extensors of the toes. These muscles become swollen when they are exhausted, and undergo the chemical and histological changes described above.

If the circulation to these muscles is already impaired by fibrosis of the anterior tibial artery, the circulation becomes definitely inadequate with the development of the increased pressure in the closed fascial space. Peritendinitis crepitans does not occur because of the ischaemia and the consequent absence of hemorrhage and deposition of fibrin.

No specific factor has been proved to be the causative agent of the arterial changes. It may be surmised that the hypertrophy and fibrosis of the media, and the fibrosis of the adventitia and periarterial tissue are the results of repeated overwhelming demands made upon the anterior tibial artery. Involvement of the adventitia may cause a reflex vasoconstriction that affects the entire collateral network. This has been demonstrated experimentally and clinically by Leriche. The additional factor of swelling of the muscle, due to chemical and histological changes

FIG. 4

Dissection of the fascia of the leg. (*From the Department of Anatomy, University of California Medical School.*)

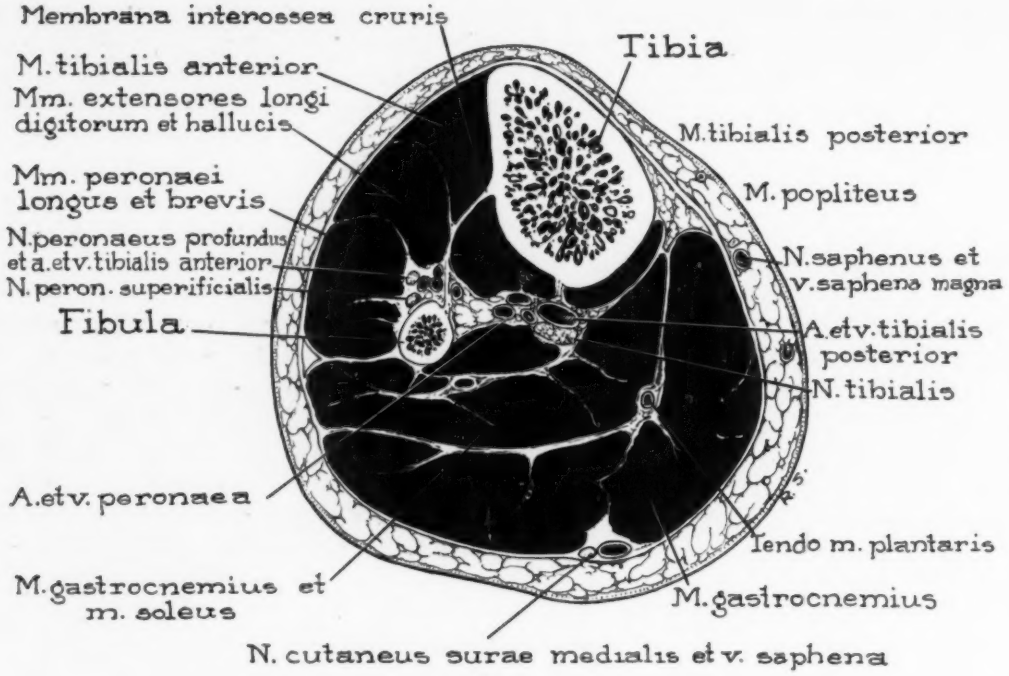

FIG. 5

Cross section of the leg at the level just inferior to the formation of the peroneal artery. (*Redrawn from A Cross-Section Anatomy by Eycleshymer and Schoemaker, and reproduced by courtesy of D. Appleton-Century Company.*)

from exhaustion, may precipitate the onset of severe ischaemia by compressing those arterial channels still remaining open.

ANATOMY

The muscles of the anterior fascial compartment of the leg are particularly vulnerable to circulatory disturbances, because of the relatively rigid walls of the compartment. Figures 4 and 5 demonstrate the relationship of the anterior fascial compartment. The compartment is bounded anteriorly by the fascia cruris, which fuses intimately with the periosteum of the tibia medially. The posterior wall is composed of the dense interosseous membrane, the fibula, and the posterior fibular intermuscular septum. This septum fuses laterally with the fascia cruris to complete the compartment. The anterior fibular intermuscular septum exists only in the upper third of the leg, and does not form a complete compartment. The fascia cruris closes the compartment superiorly, where it is continuous with the fascia lata closely surrounding the knee, and inferiorly, where it is thickened as the transverse crural ligament at the ankle. Both branches of the common peroneal nerve enter the compartment. The opening in the interosseous membrane for the entrance of the anterior tibial vessels into the anterior fascial compartment can be clearly seen in Figure 4. This aperture is adequate, so that no impairment of circulation could occur at this site.

TREATMENT

Patients having only mild manifestations of the disease have been treated expectantly with bed rest, elevation of the affected parts, splinting, and analgesics. Those patients having more marked findings have been treated by procaine block of the lumbar sympathetic ganglia, and by surgery. Block of the lumbar sympathetic ganglia may not be adequate, if segmental arterial spasm persists, due to a distal reflex arc, as suggested by Foisie, or where arterial occlusion has occurred.

Surgical treatment includes extensive fasciotomy of the anterior fascia cruris, and, in certain cases, when indicated, arteriectomy of the anterior tibial artery. Fasciotomy was sufficient to allow return of circulation in one leg of a patient having bilateral involvement.[13] Fasciotomy did not adequately improve the circulation in either of the cases reported here, but it did relieve the pressure on the branches of the common peroneal nerve, and allow their return of function in Case 2.

Arteriectomy should be performed, if pulsation does not return in the anterior tibial artery. This procedure, advocated by Leriche, has been recommended recently by Griffiths and by Foisie in the treatment of acute Volkmann's ischaemia.

Leriche believes that the obliterated artery becomes a diseased sympathetic nerve, inducing vasoconstriction in the collateral network. He has demonstrated the increase in collateral circulation following resection of the diseased artery. He reported a series of sixty cases of varied types of arterial disease, involving seventy-eight arteriectomies. There was definite relief of symptoms in 43.6 per cent. of all cases described. The greatest percentage of relief occurred in the traumatic cases, where relief was obtained in 66 per cent.

It may, therefore, be concluded that arteriectomy should be strongly considered as a therapeutic procedure in all cases demonstrating serious involvement of the anterior tibial artery.

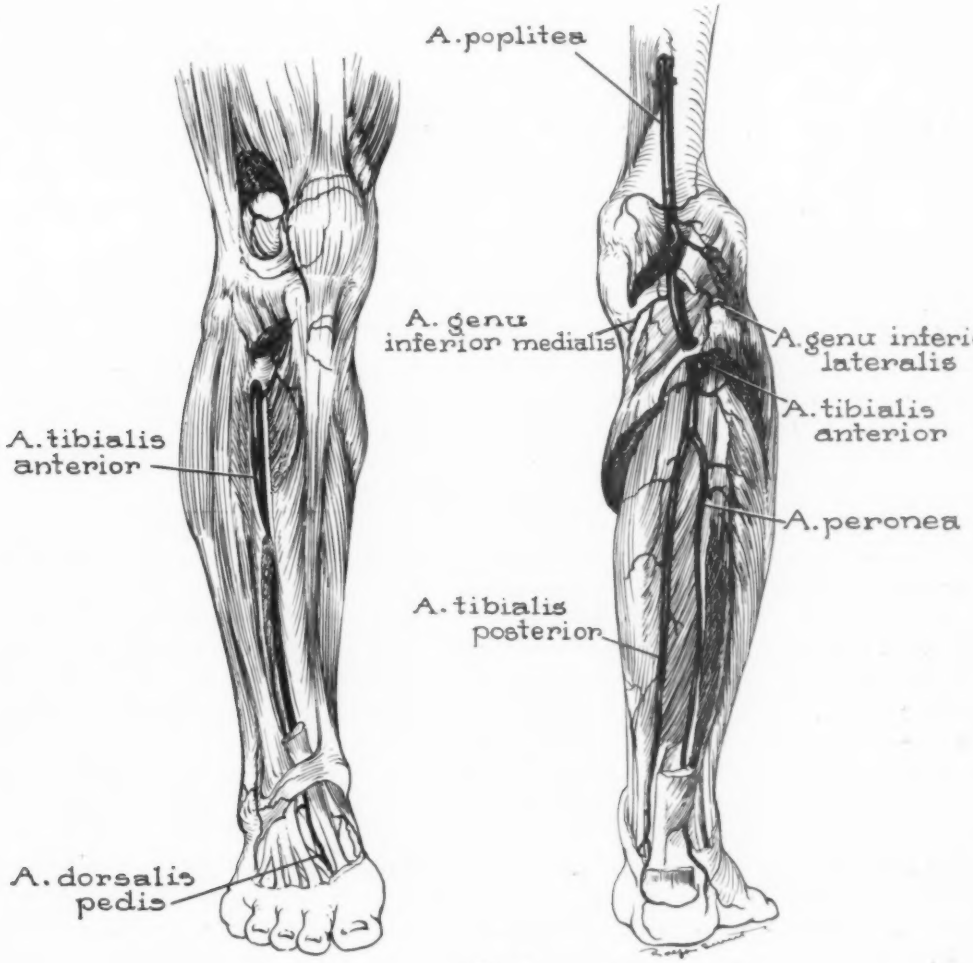

FIG. 6

Arteries of the leg. (*Redrawn from Hand Atlas of Human Anatomy by Spalteholz, and reproduced by courtesy of J. B. Lippincott Company.*)

CONCLUSIONS

1. The syndrome of localized ischaemia of the anterior tibial muscle and long extensor muscles of the toes presents a definite entity.

2. The essential vascular change is a fibrosis of the media, adventitia, and periarterial tissue of the anterior tibial artery, with ensuing occlusion.

3. The histological changes in the affected muscles are identical to those occurring in Volkmann's ischaemia.

4. The pathogenesis is obscure, but may be explained by repeated overwhelming physiological demands upon the anterior tibial artery, such as occur in long periods of training in the infantry, and in athletics.

5. The acute onset of severe ischaemia during marching is probably due to muscular exhaustion, and swelling in the anterior fascial compartment.

6. The musculature of the anterior fascial compartment is particularly vulnerable to circulatory disturbances, because of the anatomical arrangement.

7. Early block of the lumbar sympathetic ganglia and early complete vertical incision of the anterior fascia cruris improve the collateral circulation, and permit the return of function to the common peroneal nerve.

8. Arteriectomy is indicated, if segmental arterial spasm persists or if arterial occlusion is present.

9. Idiopathic claw-foot may be the result of insufficiency of the anterior tibial artery with ischaemic contracture of the anterior tibial muscle and long extensor muscle of the toes.

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SEVERE WAR INJURIES OF THE ELBOW*

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Experience on the Orthopaedic Service at the Valley Forge General Hospital has given a fair perspective on how to meet the problems of severe elbow fractures as they occur in war casualties, in the various theaters of war.

First of all, it has been found necessary for purposes of analysis to make a thorough objective examination of each patient's injury. The study should cover the complete history of the patient: how, when, and where he was wounded; what his initial treatment was; and what had been his intermediate care. Usually all of the patient's roentgenograms accompany him. As soon as convenient, new roentgenograms are taken without the plaster casts, to show the complete detail of structural derangements. The following points covered in the examination call attention to the special nature of these injuries.

1. *Nerves:* Is there any paralysis? The first check is the motor and sensory response of the ulna, the medial, and the radial nerves, because so often in shattering compound injuries about the elbow one or more of the major nerves are involved.

2. *Blood Vessels:* Three cases of obliteration of the brachial artery have shown the seriousness of circulatory complications. In two of them severe contractures of the hand and wrist followed the resulting ischaemia.

3. *Muscles:* Partial tears of many of the muscles are common and not too serious, unless innervation has been damaged.

4. *The Joint:* Each case is considered not as a simple fracture, but as a badly comminuted and disorganized elbow joint. Yet, with conservative support and protection, it is amazing to see fragments of bone and periosteum coalesce, and resolve into strong healthy bone. Gradually the joint itself regains form and detail. In the final stages of healing, motion and even active use may be permitted to determine the residual factors which must be met. Is there hinge action? Is there any rotation? What fragments are missing? Which distortion causes a block of flexion or extension? Is there non-union? Each case may present numerous and intricate abnormalities of the joint structure. For these reasons the general management of the bone comminution must be definitely conservative.

FUNCTIONAL OBJECTIVES

One must carefully analyze the residual or prospective joint function according to the following precepts:

1. *Strength:* Experience with patients gives the impression that the most desirable objective is a stable elbow to strengthen the forearm and hand. To obtain this a fixed elbow is far better than a painful or a flail elbow.

2. *Range of Motion:* If an elbow must become fixed, it will be most useful to a man doing heavy work, for example, to have it fixed at an angle of 110 to 120 degrees. A range of from 70 to 120 degrees of flexion and extension, with 50 per cent. of normal pronation and supination, gives a useful elbow.

INTERMEDIATE TREATMENT

Following this objective analysis of the problem, a plan of treatment can be laid out for the patient, and the various steps can be visualized. Each one of the following phases must be cared for in turn:

* Presented at the meeting of the Orthopaedic Club of Philadelphia at Valley Forge General Hospital, October 13, 1944.

FIG. 1-A

FIG. 1-B

Case 1. Injury occurred in Tunisia, January 1943, in collision of truck and half-track.

Fig. 1-A: Roentgenogram at time of admission, showing healed fractures of head of radius, external epicondyle, and olecranon. Rotation of only 20 degrees in pronation; flexion to 90 degrees; extension of 130 degrees.

Fig. 1-B: Postoperative roentgenogram, following removal of wire around olecranon, excision of head of radius, and projection of external epicondyle. Rotation 70 per cent. of normal; flexion to 75 degrees; extension to 150 degrees.

At the beginning, the open wounds must be carefully dressed. If the wound is deep, and bony instability is a strong factor, it is advisable to use plaster dressings for a time. As a matter of fact, most of the cases arrive from overseas in plaster casts. Plaster has its advantages: for transportation, for rest of the injured part, for support to the circulation, and for control of the bone fragments. However, the plaster is removed as early as practical. Soft-tissue healing takes place faster outside of plaster, and early mobilization of the elbow can also be carried out to advantage. Exposed bone must be trimmed back so that granulations will spread over it. Sequestra, if they are causing persistent sinuses, must be removed.

RECONSTRUCTIVE SURGERY

Reconstructive surgery on elbow joints must not be undertaken too soon. Not only must the danger of infection have passed, but also all active tissue reaction must have subsided before any operative procedure can be assured of success. The use of penicillin, before and after operation, greatly decreases the chance of infection, and permits much earlier operative intervention. Nevertheless, the postoperative proliferation of fibrous tissue, the thickening of the capsule, and the progressive phase of myositis ossificans are the dangers to be avoided by waiting until months have passed.

The best way for us to analyze the possibilities for reconstruction of an elbow joint is to follow down along anatomical lines:

A. *Epicondyles of the Humerus:* The epicondyles have little significance in severely deranged elbows. If they are destroyed, the muscle origins will re-attach themselves to the bone and fascia, and continue to function properly. In time they may regrow. Many spurs of bizarre appearance will form on the condyles as the muscle origins, which have been torn loose, become re-attached to the bone. Whenever these spurs seem to interfere with function, they are removed, as in Case 1, without any subsequent weakness of the extensors.

B. *External Condyle:* Here, function is checked by a bony block. The most common type of severe fracture of the external condyle results in rotation, and, usually, forward displacement of the capitellum in varying degree. The functional loss is limitation of flexion and extension, because of blocking by the radial head. Rotation is often nearly normal. Nevertheless, if the flexion block is beyond 90 degrees, it may be wise to resect the radial head; a decided gain in flexion will follow. The capitellum may be reshaped at times by removing the anterior deformity.

A most instructive case was one in which the external condyle was entirely missing (Case 2). Yet, this soldier had a strong, painless, and useful arm with flexion to 75 degrees, extension to 140 degrees, and complete rotation. His wrist and hand extensors worked normally, although no bony origin for the muscles could be demonstrated. Apparently, the extensor muscles attached themselves to the fascia and scar tissue leading to the shaft of the humerus. In retrospect, serious thought has been given to the relative importance of the entire external condyle. Apparently as long as enough of the trochlea remains to give stability to the swing of the olecranon, the outer condyle is not essential. Noteworthy in these cases is the fact that rotation is complete.

FIG. 2

Case 2. Soldier wounded in Italy, in January 1944, by machine-gun bullet. Final stage of bone healing, with external condyle and capitellum completely missing, yet functional result excellent. Strong, stable elbow. Rotation complete; flexion to 75 degrees; extension to 140 degrees.

C. *Internal Condyle:* The internal condyle may be fractured as often as the external, but the final results are quite different. The joint between the condyle and the olecranon may be so destroyed that eventual spontaneous fusion will take place. With this anticipated outcome, care must be taken to preserve the joint angle for greatest usefulness. Case 3 illustrates this point. The boy had a fixed olecranon, but retained complete rotation. He left the hospital with a strong right arm, and with every anticipation of resuming his occupation as a stable groom. In other cases, as in Case 4, a fair amount of motion may be preserved, even though considerable deformity results. This soldier's flexion range was from 70 degrees to 135 degrees, while the radial head remained free, and rotated normally. The result was quite satisfactory from the viewpoint of function. Such reconstructive surgery as can be performed on the inner side of the elbow is limited at this stage, but later an arthroplasty may be done.

D. *Olecranon:* The hinge action of the elbow will function with very little of the olecranon. As long as the triceps attachment is preserved, it has stability, and functions very well. In comminuted fractures of the proximal olecranon, it is advantageous to discard the fragments. In two cases the olecranon was considerably shortened, with excellent functional results.

In a number of cases the olecranal fossa was distorted and was filled with callus. Reshaping the fossa has not resulted in as much extension as was anticipated, possibly because sufficient bone was not removed. In retrospect, the writers would prefer to shorten the olecranon by as much as one-third to one-half of its proximal end, where it blocks extension. The triceps tendon would be re-attached after subperiosteal reflection. Instability of the joint will not follow. Fragments of the coronoid process of the olecranon may also be removed without the joint slipping backward in extension.

E. *Radial Head:* Loss of full rotation is the common result of comminuted or displaced fractures of the head of the radius. Experience with corrective surgery for these rotation handicaps has been quite satisfactory. Resection of the head of the radius will nearly always give 50 to 85 per cent. of the normal range (Case 1). Two patients lost the upper radius down below the bicipital tubercle without any serious impairment of function of the biceps. The attachment to the ulnar aponeurosis continued. The writers' follow-up has not been long enough to discover how many painful radio-ulnar joints develop after resection of the head of the radius. Removal of the distal end of the ulna has been a satisfactory correction for this complication in several painful radio-ulnar joints resulting from other injuries.

FIG. 3-A

FIG. 3-B

Case 3. Soldier wounded in Africa by machine-gun fire, March 1943.
Fig. 3-A: Shattered elbow shown in cast on arrival in this country. Sequestrectomies in August and September 1943.
Fig. 3-B: January 1944, final bone healing, showing bony ankylosis between olecranon and trochlea. Rotation normal.

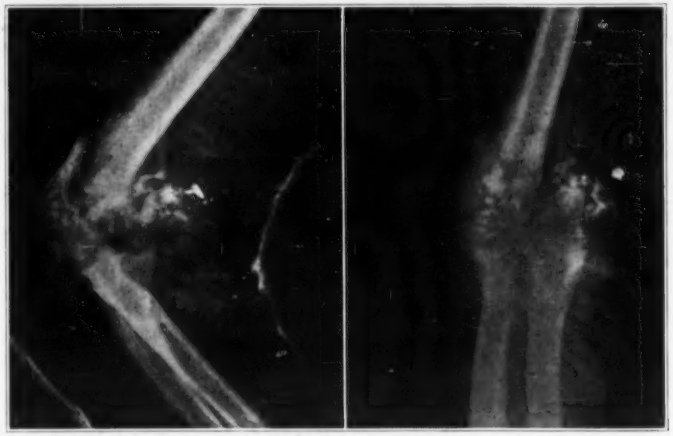

FIG. 4-A

FIG. 4-B

Case 4. Wound occurred in Italy, from machine-gun fire, January 1944.
Fig. 4-A: Comminuted condyles of humerus on arrival in this country.
Fig. 4-B: Final healing of distorted condyles. Rotation complete; flexion to 70 degrees; extension to 120 degrees.

FIG. 5-A FIG. 5-B

FIG. 6

Case 5. Soldier injured in truck accident in Italy, February 1944.

Fig. 5-A: Dislocation of elbow with fracture of the head of the radius, which was excised overseas.

Fig. 5-B: Myositis ossificans, scar tissue, and contracture of anterior capsule which restricted extension to 90 degrees. Flexion and rotation practically complete; 50 degrees of extension was gained by anterior capsulectomy.

Case 6. Soldier struck by propeller of plane, June 1943, in Libya. Synostosis between proximal radius and ulna following fracture of ulna. Rotation of 75 per cent. regained after excision of bony bridge.

F. *Anterior-Capsule Block:* This clinical entity arises from thickening and contracture of the anterior capsule of the elbow joint, with or without the deposition of calcium or the presence of bone fragments from the coronoid process of the ulna or the head of the radius. Usually the brachialis muscle has been lacerated and replaced by fibrous tissue, or myositis ossificans has developed. These cases are quite common after the usual dislocations of the elbow, as well as after the severely comminuted fractures seen by the writers. The functional handicap here is loss of extension. A satisfactory operative correction for this may be performed after a safe period has elapsed in which to allow all tissue reaction to subside. Resection of the anterior capsule of the joint, along with removal of scar tissue and bony masses, will ensure a reasonable improvement in extension. Postoperatively, these patients should wear splints, and the elbow should be in extension for three weeks. After that time, a night splint should be worn in order to prevent any tendency toward recurrence. In Case 5 there was a gain of 50 degrees by operation, a range of 70 to 140 degrees.

G. *Synostoses:* These may occur between the radius and the ulna near the joint. Resection of these bony bridges must be done carefully and thoroughly. Soft tissue must

Fig. 4-A: Comminuted condyles of humerus on arrival in this country.
Fig. 4-B: Final healing of distorted condyles. Rotation complete; flexion to 70 degrees; extension to 120 degrees.

FIG. 7-A

FIG. 7-B

Case 7. Wound was caused by shell fragments, in Tunisia, March 1943.

Fig. 7-A: False joint in supracondylar region, after soft-tissue healing, was weak and unstable.

Fig. 7-B: Realignment with fibrous union that permitted 10 degrees of motion; an additional 10 degrees of motion remained in the true joint. Rotation in true joint complete. Arm now strong and stable.

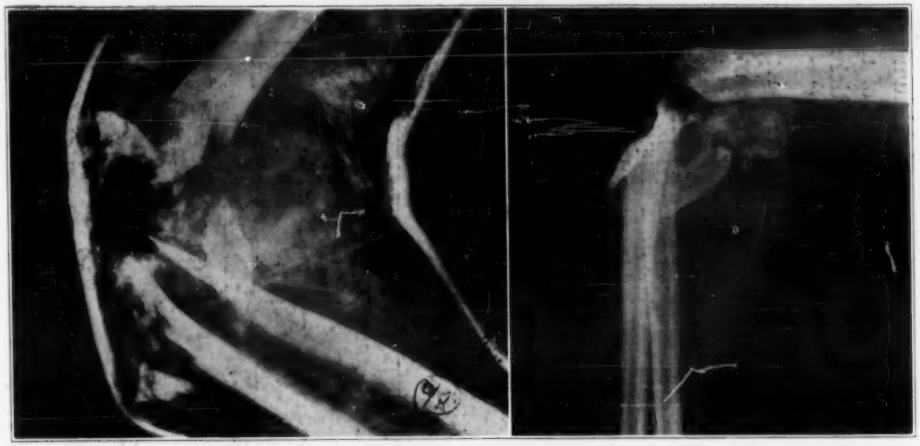

FIG. 8-A

FIG. 8-B

FIG. 8-C

FIG. 8-D

FIG. 8-E

Case 8. Soldier wounded in Tunisia, by rifle fire, May 1943.

Fig. 8-A: "Blasted" elbow on arrival. Radial nerve gone. Fig. 8-B: Flail joint after soft-tissue healing.

Fig. 8-C: Full-thickness skin flap grafted from abdomen. Then the wrist flexors were transferred into the thumb and finger extensors.

Fig. 8-D: Reposition of all three bone ends for the purpose of fusion.

Fig. 8-E: Final operation: resection of proximal radius to permit rotation. Result: strong, stable elbow with motion from 100 to 120 degrees; rotation 70 per cent. of normal; strong, useful hand with full range of function.

always be interposed to prevent their recurrence. One patient (Case 6) regained two-thirds of normal rotation. Case 8 represents a different problem, but this was solved by resecting one inch of the proximal radius; at least two-thirds of normal rotation returned.

H. *Pseudarthrosis:* This supracondylar false joint, as shown in Case 7, produced a weak, awkward action of the elbow and the hand. At operation the old bone was removed, and the fragments were replaced in relatively normal alignment, and fixed with Kirschner wires. The hoped-for union failed, probably because of the development of a low-grade infection, but the pseudarthrosis stabilized very well, with only 10 degrees of painless motion. Ten degrees of motion also remained in the elbow joint. The final analysis was: rotation complete and painless; flexion from 80 to 100 degrees with good strength. This is considered preferable to a fixed joint.

I. *Flail Joint:* What to do in case of a "blasted" elbow was solved in Case 8. During the healing of the deep wound, stability was maintained by plaster fixation. As soon as clean granulation tissue had filled in the gap, a split-thickness skin graft was applied to cover the wound. Later the plastic surgeons removed this and substituted a full-thickness abdominal flap. In due time this permitted an extensive operation to clean out the mass of scar tissue and odd bone fragments where the joint had been, and to align the radial and ulnar ends against the humerus. While firm fusion was not obtained, stability was. About 10 degrees of motion persisted, but the arm had good strength without pain. The rotation which had been lost by synostoses was restored successfully by resecting an inch of the proximal radius. It should be noted that the flexor group of forearm muscles functioned with excellent strength, even though both condyles of the humerus were missing.

FIG. 9-A

J. *Unstable Elbow from Non-Union of Proximal Ulna:* Disruption of ulnar continuity near the joint definitely results in the serious handicap of instability.

FIG. 9-B

FIG. 9-C

Case 9. Soldier, wounded in Sicily by machine-gun fire, in July 1943.

Fig. 9-A: Complete excision of deep scar over upper ulna; area covered by shifting full-thickness local flap. Residual scar was covered by free split-thickness graft from thigh.

Fig. 9-B: Showing defect in ulna, with angulation and rotation of olecranon.

Fig. 9-C: Application of fibular graft; proximal end doweled and fitted as intramedullary graft; distal end "stepped" against shaft and held by two screws with nuts and washers.

Fig. 8-E: Final operation: resection of proximal radius to permit rotation. Result: strong, stable elbow with motion from 100 to 120 degrees; rotation 70 per cent. of normal; strong, useful hand with full range of function.

While the radius serves as a guide in forward and backward motion, it acts simply as a pivot on which the forearm twists laterally when the ulna is missing. Case 9 illustrates this condition clearly. Before a bone graft could be attempted, the rotation had to be corrected by means of a series of casts, in order to realign the olecranon with the rest of the shaft.

K. *Paralyses:* Patients have been treated for persistent loss of muscle function due to injuries to the nerve in the elbow region, including the ulnar, the median, and the radial nerves. Tendon transplants for radial paralysis give excellent results. In a number of cases, the same basic muscle-transfer operation with minor variations was performed. A typical example was Case 8, where the patient's elbow joint was "blasted" out, and there was a five-inch gap in the radial nerve, which caused a paralysis of all the extensor group. Here the flexor carpi ulnaris and flexor carpi radialis were transplanted into the extensor tendons of the fingers and thumb. There is little problem with re-education. Simple occupational therapy will develop the new coordinating action of the muscles.

FIG. 10-A

FIG. 10-B

FIG. 10-C

Case 10. Soldier, wounded by shell fragment, in Algiers, in June 1943.

Fig. 10-A: Perforating wound of elbow which destroyed brachial artery, as well as fracturing internal condyle.

Fig. 10-B: Severe flexion contracture (Volkmann type), following ischaemia of forearm. Very little muscle power.

Fig. 10-C: At carpectomy (upper roentgenogram), radius was fused to second, third, and fourth metacarpals by sliding bone graft. At final operation, bone block was inserted between the first and second metacarpals to hold the thumb out for opponens action. Result: improved position of hand in relation to forearm (lower roentgenogram).

L. *Ischaemic Contractures:* To complete the discussion of elbow problems, two cases of severe muscle destruction and contracture should be included. These followed gunshot wounds about the elbow, which involved the brachial artery, and resulted in a severe contracture of the wrist and hand. After months of painstaking stretching and training of fingers and wrist, a carpectomy, with arthrodesis from the radius to the metacarpals, was required in each case. The result was well worth the effort, for the hand was brought into

a good grasping position and the tendons were loose enough so that the little strength which remained in the muscles could be used to good advantage.

CONCLUSIONS

As a result of our experience with a fairly extensive series of severe war injuries to the elbow joint, several guiding principles can be offered.

1. A careful objective examination of each patient must cover nerves, blood vessels, muscles, joints, and bones.

2. Healing of the wounds must first be obtained, the optimum position for stability and function, and the importance of preserving motion whenever possible always being kept in mind.

3. Early splint-thickness skin grafts are often needed to cover granulating surfaces. Later, full-thickness flaps may be substituted, to replace scar tissue and to permit reconstructive surgery.

4. Removal of all exuberant bony masses around the elbow is an aid in promoting function.

5. Surgery should be performed step by step, after it is ascertained each time that all tissue reaction has subsided, and the results of previous steps have been appraised. Conservatism is well rewarded, on the whole, for nature performs remarkable recoveries.

6. For each anatomical displacement about the elbow, a special type of reconstructive surgery is indicated.

7. Much of the normal elbow structure—such as the olecranon, the coronoid, the external condyle, and the head of the radius—may be lost or removed in individual cases without too seriously affecting function.

8. A careful follow-up program of physical and occupational therapy is necessary to obtain good results.

9. The primary measure of usefulness of an injured elbow is stability, so that the forearm and hand may have strength. A moderate range of motion, including rotation of the forearm, provides added basic usefulness.

DUAL PLATES FOR INTERNAL FIXATION IN NON-UNION OF FRACTURES

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Last Fall the writer was consulted by a patient with flail pseudarthrosis of the humerus of eight years' duration, with a relatively short distal fragment. The patient had only one leg, the other having been amputated at the time of the injury to the arm. However, he walked so well on his artificial leg that the disability was not noticeable.

Since two patients from whom massive grafts had been removed had suffered fractures of the donor leg some three months after the operation, some hesitation was felt in removing dual grafts from the patient's only leg, so he was sent home until another procedure could be decided upon.

In view of past experience with stainless-steel bone plates used in combination with Steele's barrel-stave grafts or Abbott's iliac grafts,[3] it seemed that dual bone plates, supplemented by iliac grafts, might achieve the desired result. Consequently, a series of paired bone plates, one of each pair being threaded for the standard bone screws, was designed. Since Murray had emphasized the necessity of fixing the fragments in two planes in order to obtain rigid internal fixation, one group of plates was designed with a curved arm, projecting from each end and in opposite directions to provide for screws at right angles to those in the body of the plate. The others were ordinary steel plates, half of which were standard, and in the others the screw holes were small and threaded.

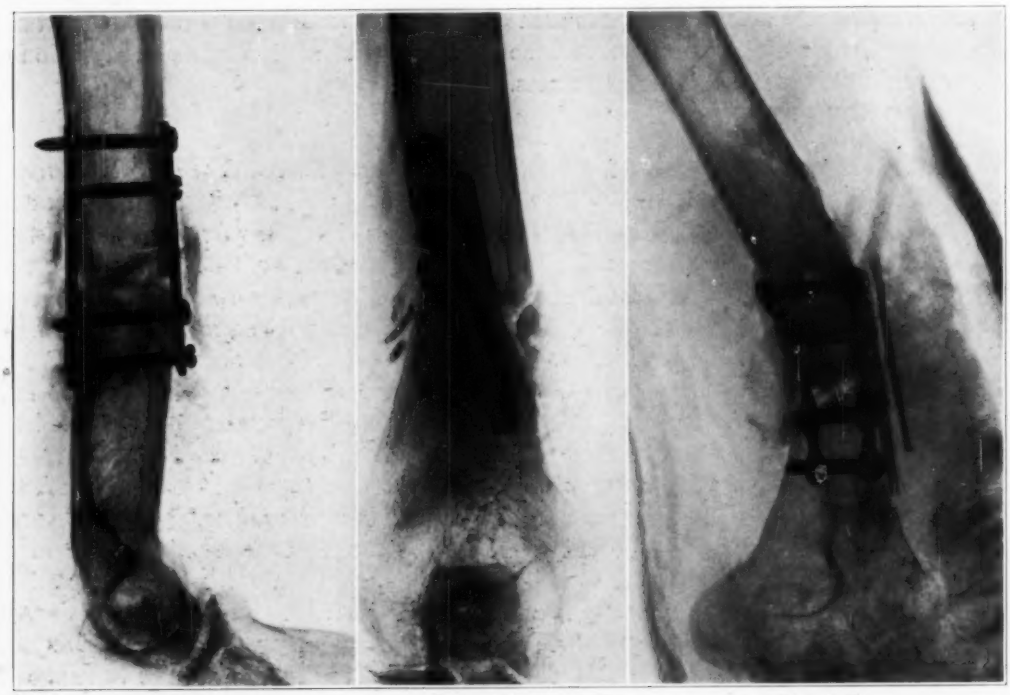

FIG. 1-A FIG. 1-B FIG. 1-C

Dual plates applied to two old ununited fractures of the humerus.

Fig. 1-A and Fig. 1-B show the plates supplemented by iliac grafts.

Fig. 1-C shows barrel-stave grafts; this humerus was purposely angulated to improve the position of the stiff elbow.

At the first operation, on an ununited and deformed femur, it was soon found that the application of the plates with the curved side arm was too difficult a procedure to be practical. Therefore, the ordinary straight plates were used, and even in the application of these, an unforeseen problem arose when it was attempted to insert the second screw. It was necessary to so drill the hole that the drill point would emerge exactly opposite the hole in the plate on the far side of the bone, and stop before it spoiled the thread in the plate. However, the difficulty was partly solved by using a small drill, which was drilled through each inaccessible and invisible hole in the threaded plate on the deep aspect of the bone. The hole was then enlarged to permit free passage of the screws through the bone. Although the threads in the last hole in the deep plate were destroyed by the drill (Fig. 1), even without this sixth screw the rigidity obtained when all of the screws were tightened was amazing. The plates acted as clamps and fixed the bones rigidly, permitting no movement in any direction.

A drill guide was at once designed, which is now available commercially, in order to make the application of the plates a practical surgical operation. It consists of a modified S-curved metal bar with a button on one end to fit into the threaded hole in the deep plate. The third at the middle of the bar is straight, and on this there is placed a guide which fits a drill (nine sixty-fourths of an inch). This guide slides up and down, and is provided with a set screw which locks the tubelike guide against the hole in the superficial plate. A drill passed through the guide strikes against the button, thus ensuring correct position of each drill hole.

In applying the dual plates, the site of the fracture is exposed through a relatively long incision, in order that with retraction two sides of the ends of the fragments can be exposed. The fracture is then reduced, and held with bone forceps, while suitable plates are selected and placed in position. If necessary, the exposed surface of the bone can be shaved or grooved with a chisel to provide a suitable bed for the superficial plate.

When the superficial plate is in place, a single hole is made straight through the bone with the drill. This hole should be made at the most inaccessible end of the plate, and should pass through the hole in the superficial plate, and emerge from the bone in the area to be occupied by the deep plate. The deep plate is then placed in position, and a screw of suitable length is passed through the end hole of the superficial plate and the bone, and is engaged in the threaded hole in the deep plate. The ends of the two plates are screwed together, but not very tightly.

After the fracture has been reduced and the plates have been applied in the desired position, the button on the end of the guide is then placed in one of the threaded holes in the deep plate, the guide sleeve is slipped down into the larger hole in the superficial plate, and the set screw on the guide is tightened to hold it in place. Then the drill (nine sixty-fourths of an inch) is passed through the sleeve and drilled through the bone until it contacts the but-

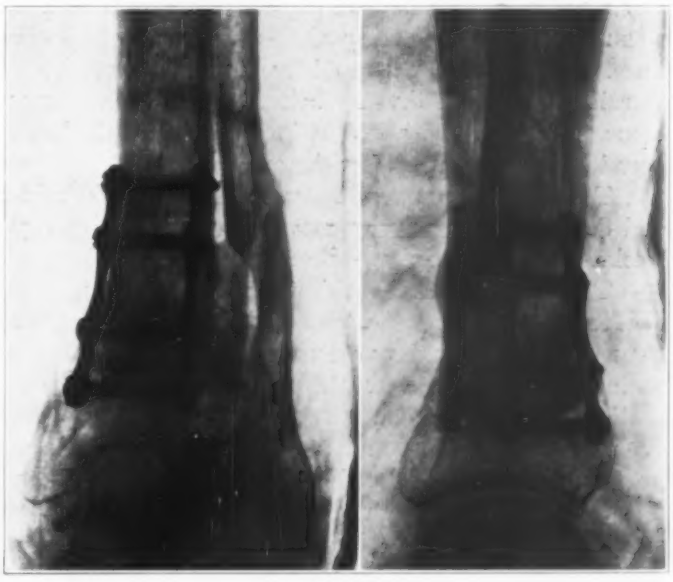

FIG. 2

Old supramalleolar fracture of the leg, fixed by dual plates plus a free (Phemister) graft on the posterior surface of the leg.

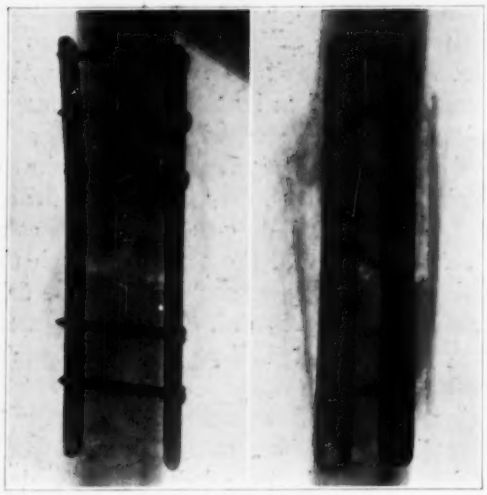

FIG. 3
Old fracture of the femur, fixed by dual plates, supplemented by barrel-stave grafts.

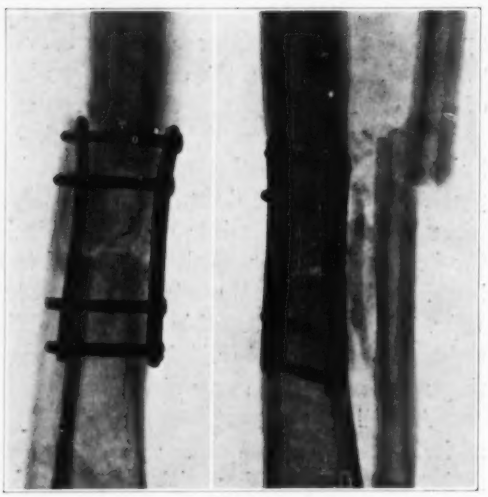

FIG. 4
Old fracture of the tibia, fixed by dual plates, supplemented by iliac grafts.

ton in the hole in the deep plate. The guide is then removed, and a screw of suitable length is inserted and tightened to a moderate degree.

The other screw holes are then treated in the same manner, and, finally, when all of the screws are in place, they are tightened to clamp the bones firmly together. The wound is then closed in the usual manner.

If one is dealing with non-union, the ends of the bones may be freshened, or revised, or subjected to multiple drilling as indicated, and the fracture site should be crossed by a free, short onlay graft of the Phemister type, or by the multiple barrel-stave grafts of Steele, or the iliac grafts of Abbott. These are supplemented by packing cancellous bone wherever it will do the most good.

The dual plates supplemented by bone grafts, either from the ilium or the tibia, have been used in seven cases of non-union: one femur, two humeri, and four tibiae. In all, satisfactory fixation of the fragments was obtained, and the fractures have united unusually rapidly. The amount of postoperative external fixation has been minimal. The femur was not splinted, and the patient was kept in bed with only a small pillow under the knee. There was no cast, and five pounds of traction was applied. This patient was able to raise his heel on the day after the operation. Four weeks after the operation he went home on crutches, with instructions to exercise the knee. Weight-bearing with a cane was permitted four months after the operation.

The tibiae were fixed in a cylinder cast to the mid-thigh for the first ten days or so, and then the sutures were removed, and a short leg cast was applied for a period of six weeks. Weight-bearing was begun gradually.

The humeri were immobilized in a posterior plaster mold, extending from the upper arm to the wrist, with the elbow flexed about 90 degrees. The wrist was suspended from the neck, and a few days after the operation swinging or pendulum exercises were started, as in the hanging-cast treatment of fractures of the humerus. Four weeks after the operation the plaster mold was removed, and the wrist was supported by a cravat sling. Exercise of the elbow and light use of the arm were permitted. These were increased gradually, and the cravat sling was discarded when the patient felt that it was not needed. The humeri were quite strong in eight weeks.

The dual plates have not yet been used for the fixation of fresh fractures, because a case has not been encountered in which they were indicated. They should be very useful to thoroughly experienced surgeons, provided further use does not disclose contraindications. There are certain objections to the dual plates:

1. A long incision is necessary, and the bone must be exposed widely. This may necessitate the partial stripping of the periosteum for a distance of two to three inches (5 to 7.5 centimeters). This may be objected to by many, but the writer thinks that such stripping of the periosteum is not apt to delay or prevent union.[3]

2. The operation may be difficult. This is especially true of the tibia, as one plate is placed on the posteromedial and the other on the anterolateral aspect, in order that both may be well covered by soft tissue. It may be necessary to chisel a suitable flat surface on the bone for the reception of each plate, in order that they may lie parallel and grip the bone firmly.

3. If the plates become loose or infected, their removal may be necessary, and this will be more difficult than the removal of a single plate.

FIG. 5

Old fracture of the tibia, fixed with dual plates, supplemented by free (Phemister) graft to the tibia. The defect from which the graft was taken is shown in the proximal half of the tibia.

4. If possible, application of the dual plates should not be undertaken without a practical drill guide or jig and a full assortment of screws. The illustrations show that the correct length of the screw is too frequently not available. Thus far the projecting screws have caused no trouble, but they may do so, and, therefore, their use should be avoided.

5. The self-threading screws with a channel are not suitable for metal, and occasionally they bind and have to be removed, and another screw substituted. Ordinary machine-threaded screws would be more suitable, and these may be available later, if this method of fixing bones is favorably received by orthopaedic surgeons.

The author has used the dual-plate method only in fractures with non-union and in conjunction with bone grafts. The operation is difficult, and leaving so much metal in the tissues is objectionable. It should be used only by experienced bone surgeons, and only in situations where rigid internal fixation is definitely indicated. It is not proposed as a routine method for the internal fixation of fractures, and its indiscriminate use should be discouraged.

A similar method of internal fixation was used by Breck and Basom in a patient with a fresh fracture of both bones of the leg. They performed open reduction, and applied a vitallium plate in the usual manner, and then placed a second vitallium plate on the opposite cortex of the femur, and fixed this plate with two vitallium bolts with vitallium nuts in the deep aspect of the wound. They controlled the direction of the screw holes by means of a jig which was clamped to the first plate and the bone. They report that the wound healed rapidly, and the patient was able to begin full weight-bearing in six

weeks. Good union was demonstrated three weeks later, and perfect results were obtained.

It is believed that the hitherto unattainable degree of internal fixation afforded by the dual plates makes them useful in properly selected cases and in the hands of a sufficiently skillful surgeon.

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TREATMENT OF UNUNITED FRACTURES OF LONG BONES

A Method Combining Grafting and Internal Fixation *

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Medical Corps, Army of the United States

This paper constitutes a preliminary report on a technique for the treatment of non-union and delayed union in fractures of the long bones, involving the use of a plate for fixation plus iliac bone as graft material. As yet, insufficient time has elapsed for a final report.

Any method purporting to be better than existing methods must of necessity be simple, easy to use, applicable to large groups of patients, not require excessive operating time, and give as good or better end results. The following method seems to meet all of these requirements. The principle of graft material plus internal fixation in itself is not new, for methods using tibial grafts with one or more plates have been advocated in the treatment of malunion.

There is, of course, controversy regarding the relative merits of cortical *versus* iliac bone as graft material. The essence of this controversy seems to be that while bone from the ilium is more readily revascularized and incorporated into the host bone because of its cancellous nature, tibial bone has the distinct advantage of being rigid enough to give good internal fixation to the host bone when fixed to it with screws. It is this quality of tibial bone which is responsible for the evolution of the classical operation for non-union of the femur,—namely, the massive tibial onlay graft. *We feel, however, that what iliac bone lacks in rigidity is more than compensated for by its osteogenic qualities, and the simple addition of a plate imparts the required stability.* The most marked disadvantage of massive tibial bone grafts, aside from their very slow incorporation into the host bone, is the weakening that results from their removal in a patient who already has one extremity that is inadequate. Any surgeon who has used large tibial grafts extensively has had the misfortune of seeing a new fracture in the donor bone. In addition, it will be recalled that the point of maximum stress on any fixation material is at the fracture site, and the incidence of fracture through tibial grafts after implantation is fairly high.

The ilium, on the other hand, can supply large quantities of bone without ill effect on the patient. For femora we have been able to get a single large onlay graft, 2.5×12.5 centimeters (one inch by five inches), which is essentially flat on both cortical surfaces. In addition, numerous sliver and chip grafts are available. This involves removal of a considerable portion of the wing of the ilium, but we have not observed a resulting limp or other untoward effect, even where both iliac crests were used.

In this series of cases, only iliac bone has been used. In fractures of the femur, six months from the date of injury has been accepted as the time indicating non-union, and four months without roentgenographic evidence of callus as the time indicating delayed union. In compound fractures, surgery was not used until six months after cessation of drainage and complete healing of the skin.

One or two points in regard to the mechanics of the procedure should be mentioned. Clay Ray Murray has shown that placement of fixation elements at right angles to each other gives the maximum stability in fracture fixation. The grafts, fixed with two screws, have therefore been placed at right angles to the plate. A full-thickness iliac graft is a rigid piece of bone; and, when fixed by this method, adds materially to the stability of internal fixation. In the instance of the femur, it was first planned to place the plate anteri-

* Presented before the meeting of the Chicago Orthopaedic Society at Vaughan General Hospital, Hines, Illinois, April 13, 1945.

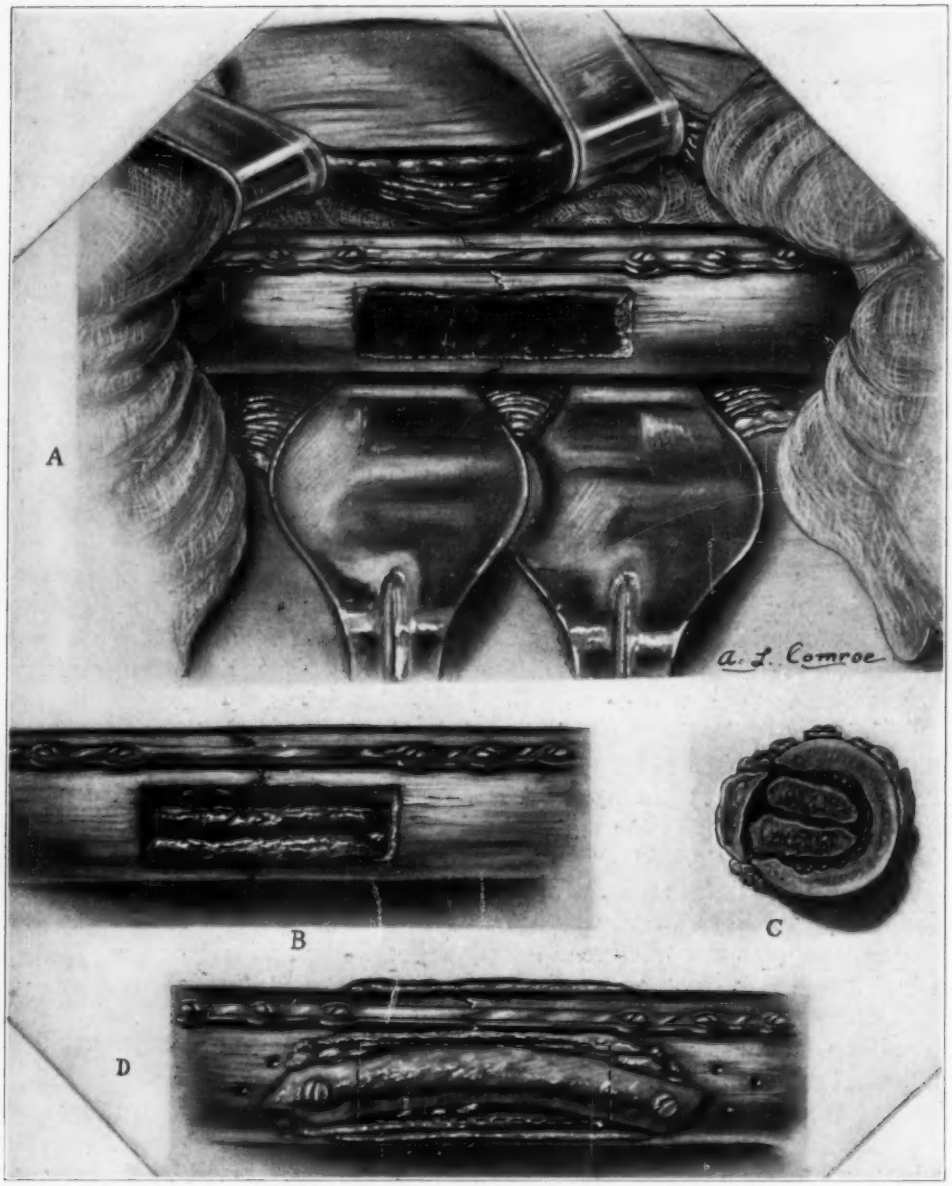

FIG. 1

Stages of operative procedure.

A demonstrates the fracture site exposed, and the fragments reduced and well approximated with plate and screws. The trough has been prepared to receive the intramedullary grafts shown in place in *B*. *D* shows the onlay graft fixed in place, the adjacent sliver grafts and multiple drill holes, while the inset (*C*) demonstrates the relative position of onlay, intramedullary, and extracortical sliver grafts.

orly and the graft laterally so that the large mass of the graft might not interfere with the quadriceps mechanism. Lateral platings had already been done in four cases, however, and since the plate should be placed at the point of maximum stress, which is usually lateral, in nine of ten femora the plates were applied laterally and the grafts anteriorly. Apparently the mass of the graft has not interfered with quadriceps function.

It is well known that, following the initial resorption of bone at the fracture site during the first few weeks, a plate often becomes a vicious factor, maintaining the gap at the fracture site and causing non-union by preventing contact of the bone ends. This fact

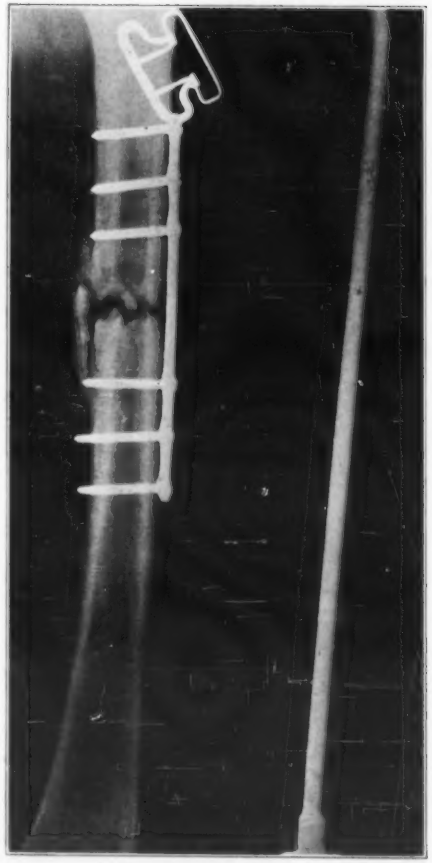

FIG. 2-A

FIG. 2-B

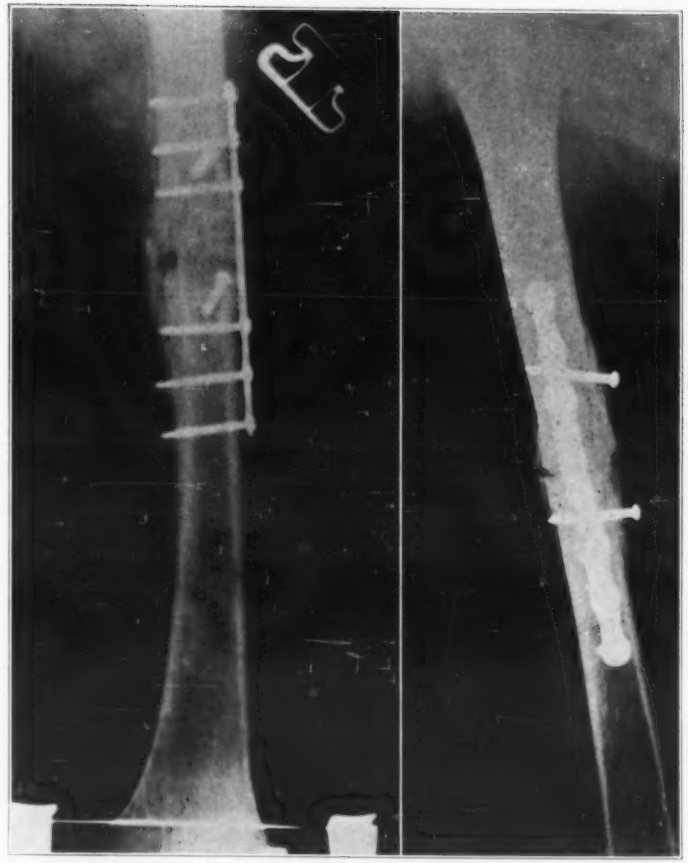

FIG. 2-C

Patient, aged nineteen years, sustained a simple fracture of the femur when he was struck by a falling log. Internal fixation was performed six weeks following injury and prior to return to Zone of Interior.

Fig. 2-A: Roentgenogram showing fracture six months following injury. Note the distraction interval at the fracture site and the small amount of callus that has formed along the medial aspect.

Fig. 2-B: Roentgenogram, immediately following combined iliac bone graft and internal fixation, demonstrates the six-screw plate left *in situ*. The onlay graft has been placed anteriorly and is held by two screws. The intramedullary grafts and multiple drill holes can be seen.

Fig. 2-C: Anteroposterior and lateral views made sixteen weeks later demonstrate the disappearance of the fracture interval, incorporation of the grafts into the host bone, and the firm osseous union. At this stage, the patient was ambulatory, in an ischial weight-bearing brace.

FIG. 3-A

FIG. 3-B

FIG. 3-C

Patient, aged twenty-one years, sustained a simple fracture of the right femur when struck by a motor vehicle. He was treated by skeletal traction in balanced suspension.

Fig. 3-A: Roentgenogram, showing apparently firm bony union, with good callus formation, five and one-half months following injury. At this time, patient was allowed to walk, in a well-fitting ischial weight-bearing brace.

Fig. 3-B: Roentgenogram, made seven days after Figure 3-A, shows refracture, which occurred while patient was getting into bed, in spite of adequate brace fixation.

Fig. 3-C: Sixteen weeks following combined iliac bone graft and plate fixation. Roentgenograms show disappearance of the fracture interval, firm incorporation of grafts into the host bone, and solid osseous union. At this stage, patient was ambulatory in an ischial weight-bearing brace.

might be used as an argument against leaving in the plate when a fracture has failed to unite, and against the use of plates at all with bone grafts. The curetting out of all fibrous tissue at the fracture site, the packing of the interval with bone chips, and the use of the intramedullary and onlay grafts to bridge the fracture site invalidate such arguments.

METHOD OF TREATMENT

Preparation

Three or four days prior to surgery, if the patient is not already in skeletal traction, a Kirschner wire or a Steinmann pin is placed in the distal femur, using local anaesthesia. On the day of surgery the patient is brought to the operating room in a Thomas splint, with the weight operating over the end of the splint. He is operated upon with the weight still acting over the foot of the table, so that his fracture is protected at all times; immediately following surgery he is returned to the ward and again placed in balanced suspension.

The usual two-day sterile orthopaedic preparation is given to the involved extremity, as well as to the opposite iliac crest. Blood transfusions are given if necessary. It is important to have the patient in as good condition as possible, particularly in cases of frac-

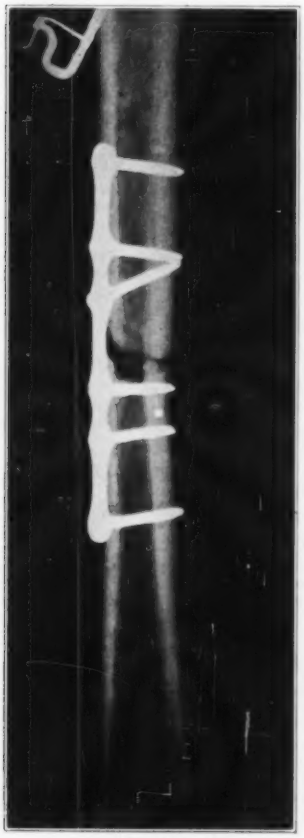

FIG. 4-A

FIG. 4-B

FIG. 4-C

Patient, twenty-seven years old, received a simple, transverse fracture of the right femur, when struck by a vehicle. Treatment was by open reduction and plating, six weeks after injury.

Fig. 4-A: Roentgenogram shows fracture five months after injury. There is no evidence of callus, and a definite distraction interval is evident.

Fig. 4-B: Roentgenogram made two weeks after patient became ambulatory in a well-fitting ischial weight-bearing brace. The fracture had bowed, and the plate had loosened following breaking of its distal screw.

Fig. 4-C: Roentgenogram made sixteen weeks following combined iliac bone graft and plate-fixation, the original plate having been re-applied more securely. The fracture site was no longer evident, union was firm, and the grafts had become well incorporated into the host bone. On this date, patient was ambulatory in an ischial weight-bearing brace.

tured femur where the patient has been confined to bed for from four to six months or longer. On the morning of surgery, an intravenous injection of normal saline solution is started as soon as the patient has been anaesthetized, and blood transfusion is substituted as soon as active bone work begins.

Surgical Procedure

The first operator, with one assistant, exposes the fracture site and proceeds with the plating; while a second operator, with one assistant, removes the grafts. A 15-centimeter curved incision is made from the anterosuperior iliac spine along the iliac crest, and the bone is exposed subperiosteally. The curves of the crest are trimmed with an osteotome, and the large graft is cut with a motor saw, beginning at the upper margin of the antero-inferior spine and proceeding posteriorly. Numerous smaller sliver grafts are then cut with the saw or an osteotome. After the grafts have been removed, the wound is packed to control bleeding, and the second team then assists the first.

In the case of a femur, a six-hole plate is applied laterally or, if a plate is already in place, it is checked for stability. With the double-bladed rotary saw a slot, 1.8×6.2 centimeters, is cut anteriorly across the fracture site, and this section of cortical bone is removed. The medullary cavity is opened at both ends, and all fibrous tissue is curetted from the fracture site. The slot is then filled with two or three sliver grafts of ilium, which can be made to fit quite firmly. The large graft is now placed over the inlay, after thor-

FIG. 5-A

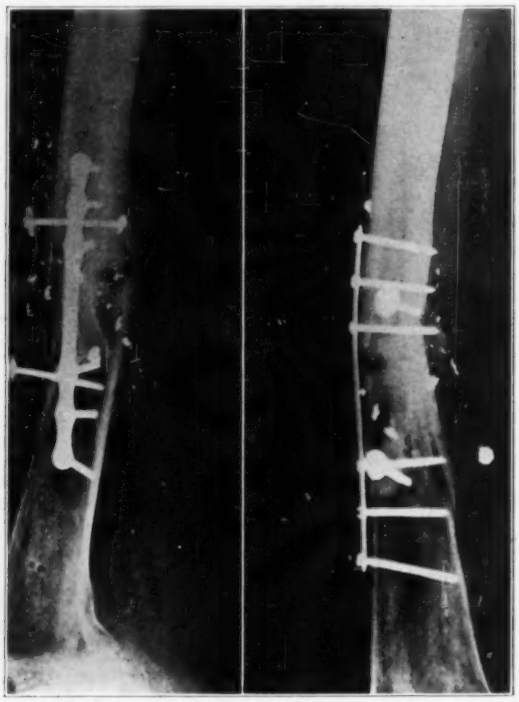

FIG. 5-B

Patient, aged twenty-one years, sustained a compound, comminuted fracture of the right femur as a result of enemy shell fire.

Fig. 5-A: Appearance of fracture eight months after injury. There is no callus formation, and a complete non-union is present. The lateral bowing became exaggerated after the patient had been allowed up in an ischial weight-bearing brace for two weeks. The numerous metallic bodies in the region of the fracture are shell fragments.

Fig. 5-B: Roentgenograms, made immediately postoperatively, show very strikingly the mechanical principles of the combined operation. The massive illiac bone graft, held with two screws and washers, has been placed across the fracture site, overlying the trough with intramedullary grafts, at right angles to the six-screw plate. This patient was ambulatory, sixteen weeks following operation, in an ischial weight-bearing brace, osseous union being firm, and the graft well incorporated into the host bone.

FIG. 6-A

FIG. 6-B

FIG. 6-C

Patient, aged twenty years, sustained a simple transverse fracture of the left tibia and fibula in a plane crash.

Fig. 6-A: Position of fragments prior to open reduction.

Fig. 6-B: Fracture was immobilized with four-screw plate and fixation screw. Five months after injury there was no callus present, and a distinct interval was evident at the tibial fracture site. The fibula was well united.

Fig. 6-C: At operation, the original plate was not disturbed, but the transfixion screw was removed. Roentgenograms, six weeks following the operation, show the graft viable and already well incorporated. Patient was allowed to bear weight in a walking cast at the sixth week after operation, and in a tibial caliper brace at the fourteenth week, at which time complete bony union was present.

ough drilling of its contact surface. Because of its greater length, this onlay graft extends over cortical bone beyond the limits of the inlay. The graft is fixed with two screws, which usually pass between the first and second and the fifth and sixth screws in the plate. The heads of these screws are often widened by addition of a flat washer, to prevent their cutting through the soft iliac bone. The screws engage both cortices of the host bone after passing through the graft. Just before placement of the grafts, the fracture ends are thoroughly drilled as an additional aid to union. After the grafts have been placed, the second team closes the iliac incision, while the first closes the extremity incision (Fig. 1).

Postoperative Care

All of the femora have been treated with skeletal traction in a Thomas splint as the only fixation. Twelve pounds of weight are used on a Steinmann pin or Kirschner wire through the distal femur. In ten patients operated upon, this has been adequate, and in no patient has position been lost. The patients are quite comfortable, and early knee motion is instituted. This feature of the procedure is made possible by the addition of the plate to the bone graft. The skeletal traction has been changed to skin traction after ten or twelve weeks in all cases. It may be found possible to make this change earlier. The first five patients in this series have become ambulatory in ischial weight-bearing braces sixteen weeks after the operation.

RESULTS

The indications are that very rapid union and incorporation of the graft from the ilium occur, as will be seen in the following analysis. Sixteen operations have been performed by this technique.

Ten were for fractures of the femur, three of which were compound. Surgery was not attempted in the compound fractures until six months after cessation of drainage. The actual time before operation in these ten cases ranged from three to nine and one-half months from the date of injury. In four of the simple fractures, platings had been done from one to six weeks following injury. At the time of operation, all patients had complete non-union or delayed union, without evidence of callus. Only one patient was operated upon as early as three months after injury; this was done because of marked displacement of bone ends, with interposition of soft tissue. Results in these ten cases of fracture of the femur are as follows: Five are solidly united and the patients became ambulatory, in ischial weight-bearing calipers, sixteen weeks following operation. This includes one patient who, in addition, had a non-union of the opposite tibia, which was also grafted with ilium, and the patient was made ambulatory in a cast and brace. The other five patients were operated upon less than sixteen weeks before the date of this report, but each is showing the same rapid incorporation of the grafts. No complications have occurred (Figs. 5-B and 6-C).

Four patients had fractures of both bones of the forearm, two compound and two simple, three of which were plated two weeks after injury; in all four there was non-union. Bone-grafting was done from six to nine and one-half months after injury, in the same manner as that described for femora. There have been no complications. All four patients have obtained solid union in twelve weeks or less.

One simple fracture and one compound fracture of the tibia complete the series. The simple fracture had been plated four days after injury, and an additional transfixion screw had been inserted. In this case an iliac graft was used five and one-half months after injury. The patient was ambulatory, and the bone was firmly united fourteen weeks after the operation (Fig. 6-C). The compound fracture presented a considerable defect, due to loss of bone, and fixation was obtained by means of a six-screw plate and a flange bone graft. The patient has been operated upon too recently to evaluate the results.

In all cases there was healing without infection, and there were no complications except one malarial relapse three days after operation.

RESTORATION OF MUSCLE POWER BY HEAVY-RESISTANCE EXERCISES

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Exercise is essential in restoring function to muscles, weakened and atrophied as a result of injury and disease. Therapeutically, exercises may be classified according to the quality developed in the exercised muscle,—namely, power, endurance, speed, and coordination. Failure to discriminate between these classes of exercises leads to the employment of the wrong type of exercise to develop the quality needed in the muscle; inevitably the result is poor. Commonly the attempt is made to restore power by exercises to build endurance; this is a mistake.

This paper deals with the redevelopment of muscle power, chiefly in the quadriceps, although some consideration will be given to other muscles.

PRELIMINARY CONSIDERATIONS

Most injuries of the thigh and knee result in atrophy of the quadriceps of varying degree. When the local injury has healed, redevelopment of quadriceps power is the most important factor in restoring normal function to the extremity. The method here presented for developing muscle power by exercise is founded on the principle of heavy-resistance and low-repetition exercises, whereas the generally accepted principle is low-resistance and high-repetition exercises—such as stationary-bicycle riding, lifting light sandbags or other weights through ropes and pulleys, stairclimbing, *et cetera*—which develop endurance rather than power. The fatigue that results from the latter is not due so much to overcoming resistance, as to the sheer number of repetitions; therefore, such exercise does not develop power. If low resistance is used for a low number of repetitions, no significant increase in either power or endurance results, and the only value lies in increasing slightly the joint motion. On the other hand, in our method we employ heavy resistance that calls forth all the potential strength of the muscle. Since the rate and extent of muscle hypertrophy is usually proportional to the resistance the muscle must overcome, strength returns faster than in the low-resistance exercises. We believe this to be true, because we have seen many patients fail to obtain any appreciable quadriceps hypertrophy during several months of low-resistance exercises; whereas, with the heavy-resistance exercises, we have uniformly recorded rapid hypertrophy (in several instances two to two and a half inches of hypertrophy of the thigh muscles within six to eight weeks). Power is developed in the affected thigh until it equals that in the normal. When the strength of the limbs is approximately equal, then endurance exercises may be begun. Rather than attempt to develop endurance in an atrophied, weakened muscle, it seems more logical to restore muscle strength to normal, and then build endurance by means of low-resistance, high-repetition exercises.

The quadriceps exercise described is particularly valuable, for it develops maximum power without weight-bearing. Since it is a non-weight-bearing exercise, it is especially useful in redeveloping the musculature following meniscectomy, and in unstable knees. In these two conditions, particularly when there is quadriceps atrophy, weight-bearing exercises (such as bicycling, stairclimbing, *et cetera*) frequently cause swelling and fluid. Except in rare instances, we have seen neither swelling nor fluid on maximum exertion with these non-weight-bearing exercises. In most of our cases, these symptoms have actually completely subsided on exercise. After these patients have succeeded in restoring

normal power to their injured limbs, they are able to do the light weight-bearing exercises mentioned without either symptom developing.

PROGRAM OF EXERCISES

In this program of heavy-resistance exercises, the patient exerts his maximum power only once a week. The maximum quadriceps power for clinical purposes is taken to be the maximum poundage that can be raised to the point of complete extension of the leg, for one repetition. It is recorded in pounds. Once each week the patient exerts the maximum effort of which he is capable for one repetition. On the other days, no weight heavier than that which is maximum for ten repetitions is used. This program of periodic maximum muscular exertion is used even on the most atrophied muscles. Contrary to the popular belief that after injury the quadriceps should never be exercised to its limits, we have never produced chronic muscle sprains or failed to achieve return of muscle power.[2] On the basis of clinical observations in 300 cases in which this program of exercises was used, we firmly believe that even extremely atrophied muscles should exert their maximum effort at regular intervals.

Description of Exercise

The patient is seated on the table with his knees flexed at an angle of 90 degrees, and the boot is strapped on the foot. A folded blanket or pad is placed under the knees. The patient is now in the starting position, as illustrated in Figure 1. The leg is extended as completely as the disability will permit. The leg should be extended and lowered at the same rate. The movements are done smoothly, rhythmically, and without haste, but not so slowly that the mere holding of the weights will tire the patient. Quick or sudden motions while exercising are to be avoided. A momentary pause at the end of each repetition is advocated.

The importance of complete extension with each repetition cannot be overemphasized. The vastus medialis functions chiefly by carrying the leg through the last 15 degrees of extension. The disproportionately rapid atrophy of this muscle following injuries of the lower extremity and prolonged immobilization with resultant inability to completely extend the leg is a familiar clinical picture. Restoration of strength to the vastus medialis is a major problem to orthopaedists and physical therapists. If there is sufficient strength present to carry the leg either partially or completely through the last 15 degrees, the problem is not too great. However, if there is complete inability to extend through the last 15 degrees, the problem calls for more strenuous measures. In these cases it would be im-

FIG. 1
Quadriceps exercise, using one boot.

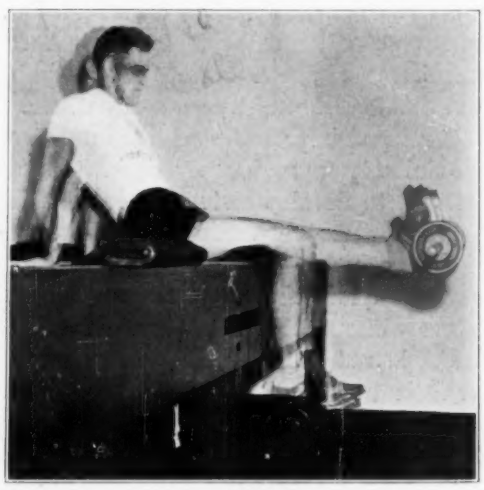


FIG. 2
Quadriceps exercise, using two boots.

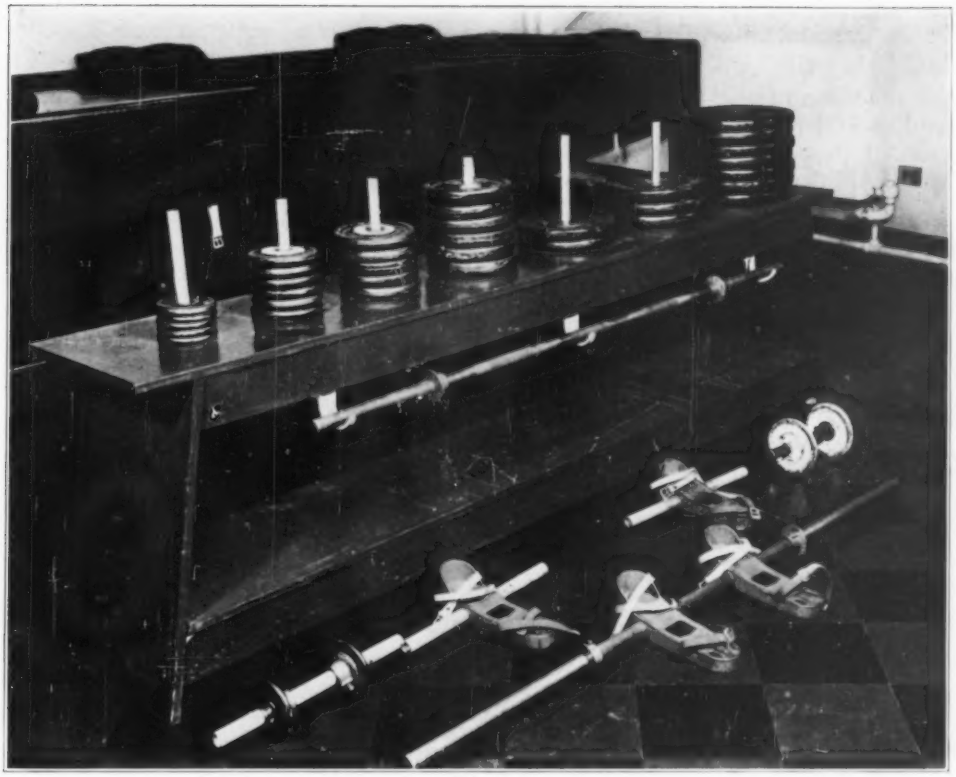


FIG. 3

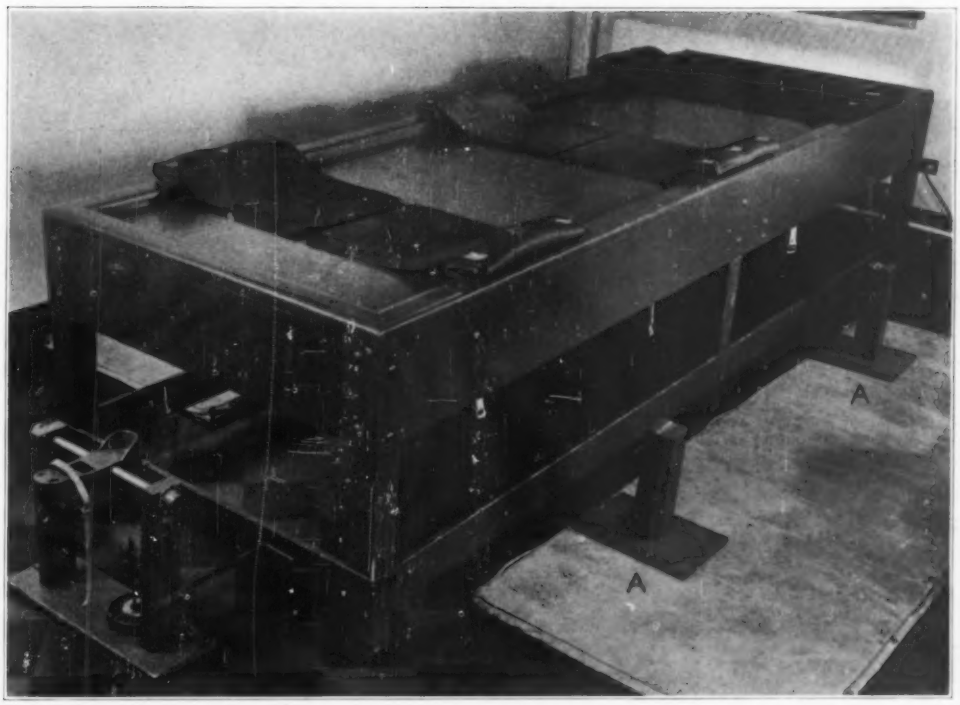


FIG. 4

Quadriceps-exercise table. The weight stands (*A*) are to rest the weight upon between sets of exercises.

possible to redevelop vastus medialis power, if the only function of this muscle were extension in the terminal 15 degrees; but the muscle also functions through a much larger range of motion when the leg must overcome a very heavy load. This fact makes it possible to exercise the vastus medialis actively in the available range of extension, thereby building power that will eventually make it possible to completely extend the knee. Sufficient vastus medialis power to produce complete extension can be built by using heavy resistance through the available range of motion. On each repetition, when the patient has reached his maximum extension, he should be taught to expend an extra effort at this point to attain even more extension.

At the beginning of the exercise and until the limbs are approximately equal in strength, only the affected extremity is exercised. Only one boot and a short bar are used, as shown in Figure 1. When the limbs are approximately equal in strength, then they are exercised simultaneously, using two boots attached to a long bar as shown in Figure 2. It is advisable for the patient to use two boots for a while to increase strength in the unaffected extremity, since this extremity becomes considerably weakened from disuse. When both boots are used, the principles of exercise, poundage increase, repetitions, *et cetera* remain the same as when one boot is used.

Apparatus

Resistance is offered in the form of iron plates, graded from one and a quarter to twenty-five pounds each. These plates are attached to an iron boot by means of a short iron pipe which fits into the boot. This boot is made especially for leg exercises. The iron boots, plates, and bars are shown in Figure 3.

The exercises are performed on a table which should be thirty-six inches high and at least fifty inches wide. The legs and top of the table should be of heavy material and reinforced, since it will be subjected to considerable strain. The edge should be raised two to three inches so that, when the leg is completely extended, the entire limb will be parallel to the floor. The quadriceps-exercise table is shown in Figure 4.

Repetitions and Weight

Fifteen is the maximum number of repetitions ever performed in series, regardless of the amount of weight lifted. Ten or twelve is the number generally performed. The total number of repetitions for an average exercise period varies from seventy to 100,—that is, seven to ten series of exercises with ten repetitions in each.

The Ten-Repetition Maximum (10 R.M.)

The amount of weight lifted by the patient at any single extension during his first week of exercise is determined at the time of his initial workout, as follows: Starting with the weight of the boot (five pounds), and increasing by small amounts (one and a quarter to five pounds), the patient lifts each weight ten repetitions. That weight which requires maximum exertion to perform ten repetitions is thus determined. For the remainder of the week, no weight heavier than this ten-repetition maximum (10 R.M.) is used. Once each week the patient makes an attempt to increase this 10 R.M., and, when this amount is determined, no heavier weight is used during the ensuing week. For example, a patient in his first workout finds that the heaviest weight with which he can perform ten repetitions is twenty pounds. Thus, during his first week, he uses nothing heavier than twenty pounds. At the end of the first week, the 10 R.M. is again determined, and found to have increased to thirty pounds. Then thirty is the maximum poundage used during his second week of exercise, *et cetera*.

Since seventy to 100 repetitions must be performed in each workout, and each poundage is done ten repetitions, the workout must be begun with a weight considerably less than the 10 R.M., so that when the 10 R.M. has been reached, seventy to 100 repetitions will have been performed. The example given can be continued to illustrate this. The

10 R.M. for the first week was twenty pounds. By starting with two and a half pounds, plus the weight of the boot, and increasing one and a half pounds after each series of ten repetitions, eighty repetitions will have been performed when twenty pounds is reached.

The One-Repetition Maximum (1 R.M.)

As previously stated, once a week the patient exerts his maximum quadriceps power (maximum weight that can be lifted with one repetition, the knee going into complete extension). This one-repetition maximum (1 R.M.) is determined on the same day as the 10 R.M., in the following manner: When the 10 R.M. has been determined, the increases in weight are continued. With each increase beyond the 10 R.M., fewer repetitions can be done until finally that weight which can be extended only for one repetition with maximum exertion is reached. This is recorded weekly as the index of quadriceps power.

As strength returns to the muscle, the weight increases may be five to ten pounds, rather than one and a quarter to two and a half, thus keeping the total number of repetitions for a workout within the range of seventy to 100.

Of course there are many patients who, because of severe quadriceps weakness, have an initial 10 R.M. of less than five pounds. In these cases, the procedure is altered, and we use two or three series of ten repetitions each without any weight, add one and a quarter pounds, and give two or three series more. Then, by increases of one and a quarter pounds, his 10 R.M. is finally determined. (When the patient is unable to begin the exercises with the weight of the boot, five pounds, the smaller weights are attached to the foot by means of a leather strap.)

In those cases where there is incomplete extension due to muscle weakness, the program is further altered. After the patient has performed ten repetitions with the maximum poundage which can be extended to the same degree as when no resistance is being applied, he then continues to increase the poundage at the sacrifice of extension. The poundage increase is continued until the knee can be extended only a few degrees. Exercising in this way through the available range of motion is necessary where muscles are extremely atrophied, in order to build enough power eventually to effect complete extension. This is especially true when the vastus medialis is weak.

Frequency and Length of Workout Periods

The patient exercises once a day, five days a week, the workout period usually lasting one-half hour. He is encouraged to rest his leg as much as possible during the two days he does not report for the exercises. Since the exercise periods are short and come only once daily, the patient does not tire of the program, as is often the case when an exercise must be practised hourly or several times a day.

Data Recorded

The following measurements are recorded weekly:

1. Range of motion,
   a. Extension,
   b. Flexion,
2. Thigh circumference,
3. Power,
   a. 1 R.M. (one-repetition maximum),
   b. 10 R.M. (ten-repetition maximum).

The weekly determination of the 1 R.M. and the 10 R.M. is made on the same day. For convenience, we designate Friday as the day on which the quadriceps power is determined. There should be a two-day rest following this day of maximum exertion, and this arrangement makes it unnecessary for the patient to exercise over the week-end.

The thigh is measured once a week, at a constant level. Silver nitrate is used to mark

the level, to make sure that every measurement is taken in the same place. Daily observations are made for development of fluid, swelling, pain, *et cetera*.

The maximum quadriceps power is determined, and thigh measurements of the unaffected extremity are taken, when the exercise program is initiated. Maximum results have been obtained when both extremities are equal in power, circumference, and range of motion.

OBSERVATIONS

Symptoms Developing as a Result of Exercises

The only symptom that developed as a result of exercise was soreness of the quadriceps muscle. This soreness invariably disappeared within a week. In no instance has swelling or fluid appeared in the knee joint secondary to the strenuous exercises.

Development of Power in the Existing Range of Motion

Too often the main stress is placed on increasing motion in the atrophied, weakened limb with a limited range of motion, and very little or no thought is given to developing power. Nicoll states that "range without power is worse than useless, for in its extreme form we have a flail joint".[2] The return of power should accompany return of motion. It is more desirable to have normal power in the existing range of motion than to sacrifice development of power for a wider range of motion. The exercises we advocate are planned so that return of power accompanies return of motion. We believe that range of motion increases more rapidly with increasing muscle power, except when a mechanical factor prevents return of motion.

Focal Exercises versus Group Exercises

We are convinced from our observation of patients indulging in group exercises and games, as performed in reconditioning programs, that group exercises for focal muscle redevelopment are unsatisfactory because:

1. The mental factor governing muscle exertion is such an important one in attaining maximum results that the patient must concentrate completely, and actually watch (whenever possible) the muscle being exercised throughout each repetition. Group participation offers too many factors to divert the patient's attention.
2. If a patient is unable to perform the movements as well as others in the group, he may feel his inadequacy to such an extent that he will attempt to cover up his weakness by adopting compensatory trick movements, thus accomplishing the feat with other muscles than the one which he is attempting to redevelop.
3. For the patient who must be prodded along, it is much easier for him to conceal his half-hearted efforts in group exercises.
4. Since there are individual variations in strength, symptoms, and types of injuries, it seems illogical to give exercises to groups of patients with the same repetitions, motions, resistance, and tempo.

Endurance versus Power

We feel that in the past one of the shortcomings of the conventional type of physical therapy for redeveloping musculature has been a failure to discriminate between endurance-building and power-building exercises. By "power-building" exercises we mean exercises in which heavy resistance is used for a low number of repetitions. "Endurance-building" exercises are those in which low resistance is used for a large number of repetitions. These are two entirely different types, each one producing its own results, and each being wholly incapable of producing the results obtained by the other. We feel that most current attempts to redevelop musculature are based on exercises which are, in the final analysis, endurance-building and not power-building in nature. We feel it is wrong, for example, to put a patient with an extremity weakened by injury on such endurance-building exercises

as stairclimbing, walking, bicycling, and similar low-resistance exercises, until the extremities are approximately equal in strength.

A muscle exercised solely on power-building exercises will not have the quality of endurance, whereas a muscle subjected exclusively to endurance-building exercises will not have the quality of power. However, a powerful muscle can be given endurance-building exercises, and attain the quality of endurance; likewise a muscle with great endurance can attain power through the power-building exercises. How illogical it would be for a track man to train for long-distance running events solely by doing knee bends with heavy weights on his shoulder, or a professional weight-lifter to train for heavy lifts solely by running several miles a day!

It seems more logical to restore the weakened extremities to normal strength by power-building exercises and then to exercise for endurance. Endurance is a quality of normal muscle, and therefore should not be sought after until the muscle has returned to normal. We believe it unlikely that endurance can be attained in a markedly atrophied muscle, for we have seen many patients who had been on low-resistance, high-repetition exercises for months, and still complained of rapid tiring of the muscle.

Physiological Aspects of the Heavy-Resistance Exercises

It is not the purpose of this paper to discuss neuromuscular or muscle physiology. We are presenting only the clinical observations made on 300 cases in which these exercises have been employed. The splendid response in muscle hypertrophy and power, together with symptomatic relief, seems to vindicate any possible violation of physiological principles. Competent physiologists who have observed these patients and our method of exercise feel fairly certain that the fatigue produced is at the neuromuscular junction, and not of the muscle fiber itself.

The question arises as to whether it is advisable to induce maximum loads on weakened and atrophied muscle fibers. We firmly believe, on the basis of our clinical observations, that even atrophied musculature must be submitted intermittently to maximum loads, in order to obtain maximum hypertrophy. We have treated several cases of fractured femur which had been immobilized from six to fourteen months. The thigh muscles were very hard on palpation, suggesting fibrosis, and lacked power. These responded in four to five weeks, showing an increase in thigh circumference of one to two inches and a remarkable increase in power. They were under maximum loads at regular intervals from the very beginning. It was interesting to observe how quickly these muscles softened and assumed the consistency of normal muscle. This observation throws an interesting light on hypertrophy and return of power in fibrotic muscle.

We believe that, in order to produce in muscle maximum hypertrophy, the heaviest load should be imposed upon the muscle as it approaches complete contraction, and not when the muscle is stretched. It is an accepted physiological principle that the greater the initial stretch or tension on a muscle (length), the greater the contractile power of the muscle. Therefore, when the maximum load is imposed on a stretched muscle, its fibers have the initial advantage rendered by the stretched state, and fewer fibers can overcome the resistance than if the muscle were not stretched. When the muscle fiber is contracted, it does not have this advantage. In order to overcome the resistance, a greater number of fibers are called upon; more fibers are exercised and thus stimulated to hypertrophy. Also, by increasing the load as the muscle reaches the contracted state, a higher degree of coordination of the contracting muscle fibers is obtained, increasing the contractile power of the muscle as a whole. Most of the power-building exercises here described are so arranged that resistance increases as the muscle contracts.

The use of a pulley system for quadriceps redevelopment has the disadvantage that the maximum resistance comes when the muscle is stretched. The pulley system as contrasted with our method is demonstrated in Figures 5-A, 5-B, 5-C, and 5-D. We do not

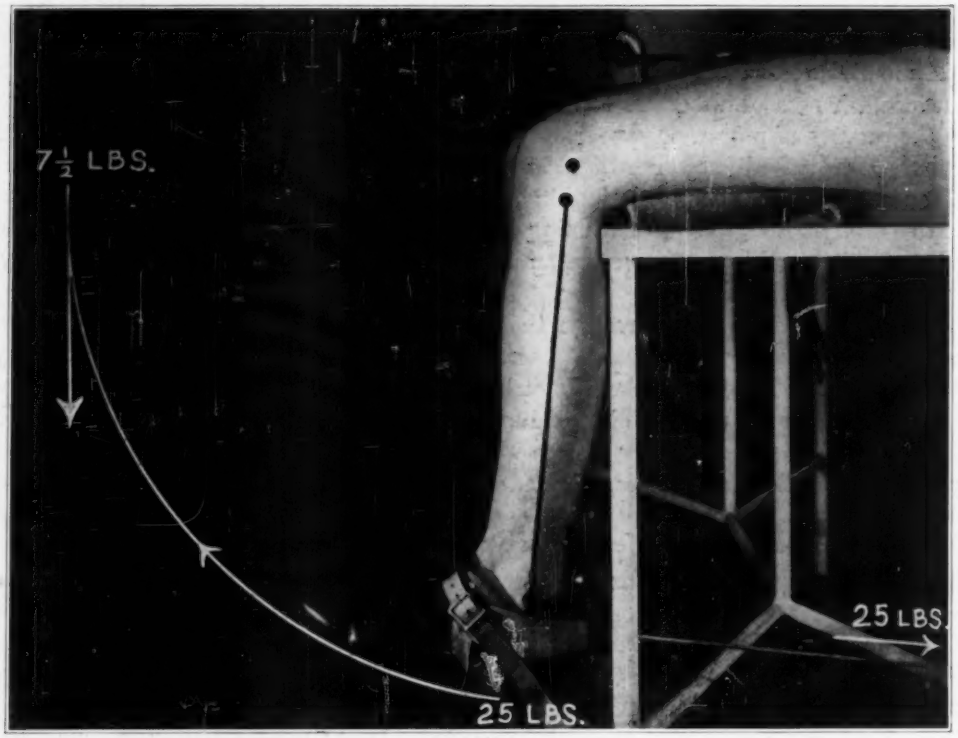


FIG. 5-A

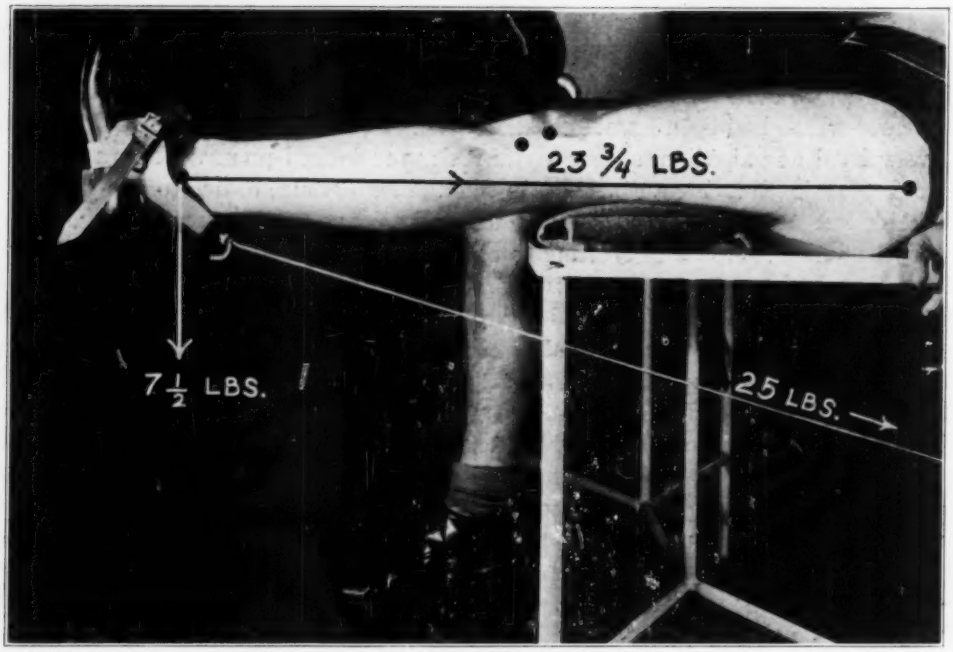


FIG. 5-B

The pulley system with knee flexed in starting position is shown in Fig. 5-A. There is 25 pounds of resistance on the pulley system, applied to the leg through the rope shown attached to the foot. The long axis of the leg in the starting position is perpendicular to the rope. At this point the resistance consists of the full 25 pounds. However, as the leg extends, the rope comes to lie at a more acute angle to the shaft of the leg, and the amount of resistance to be overcome decreases; so that, when the leg is fully extended (Fig. 5-B), the resistance to be overcome has decreased to only 7½ pounds. In full extension, 23¾ pounds of the initial 25 pounds of resistance are lost as a compression force in the direction indicated by the arrow, leaving as a resultant of forces, only 7½ pounds of resistance to be (*Continued on page 653*)

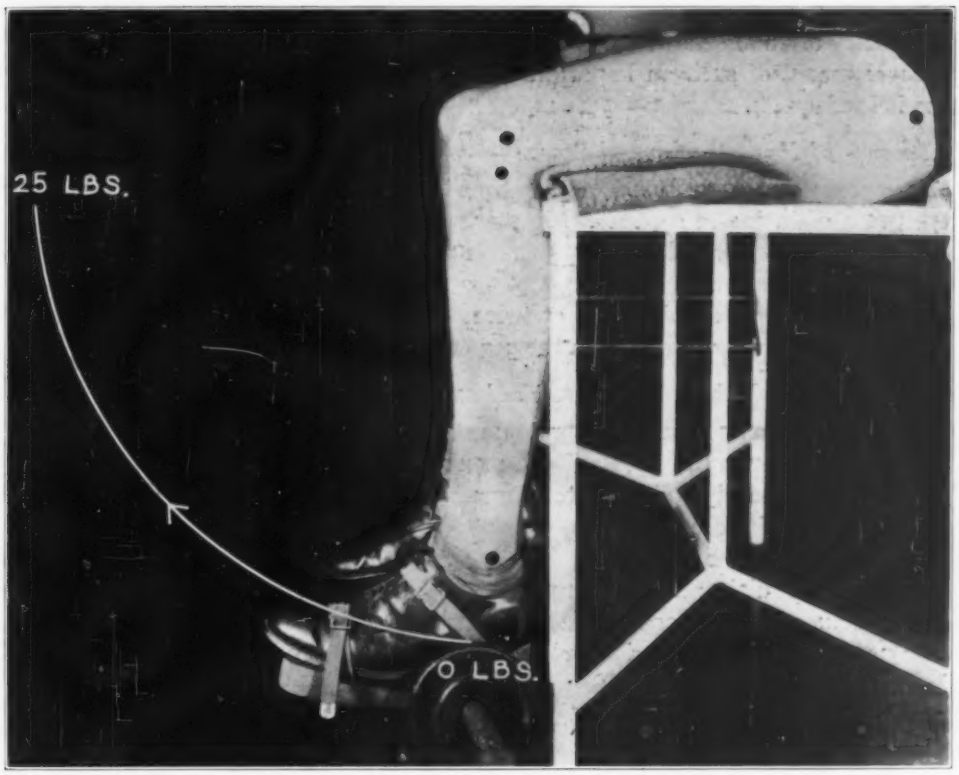


FIG. 5-C

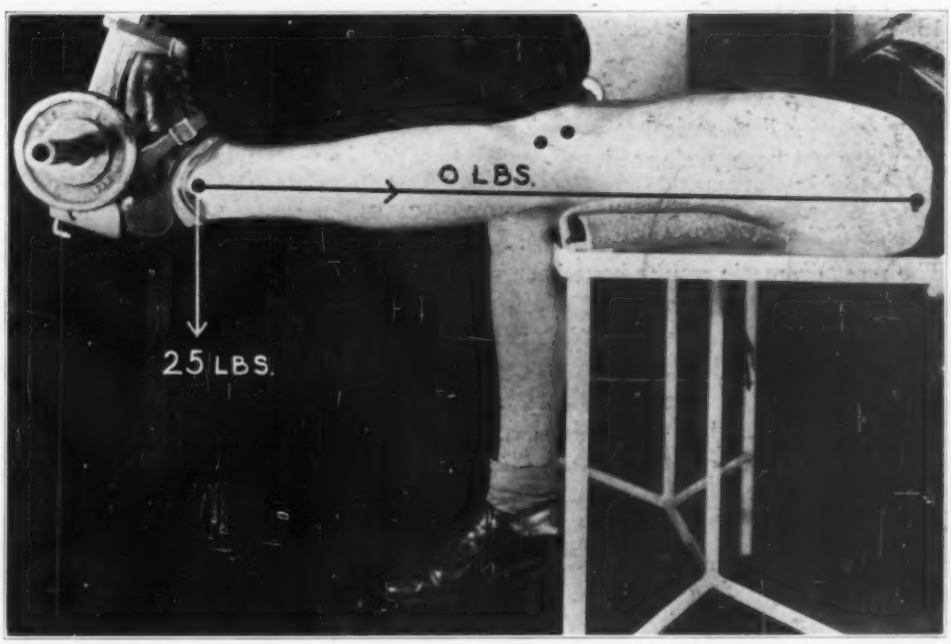


FIG. 5-D

(*Continued*) overcome by the quadriceps. Thus we see that the pulley system is one of decreasing resistance as the leg goes into extension. Therefore, when that part of extension controlled chiefly by the vastus medialis is reached, the resistance has greatly decreased; thus this muscle is neglected in the strenuous phase of the exercise.

When the resistance is added directly to the foot, the reverse of the above situation exists. In the starting position (Fig. 5-C), the resistance is practically nil; but, as the leg extends, the resistance rapidly increases and is maximum (25 pounds) when the leg is completely extended (Fig. 5-D). There is no compression force as is present in the pulley system. The vastus medialis receives the chief benefit from this exercise.

mean to imply that pulleys are of no value in giving heavy-resistance exercises; on the contrary, they often afford the only means of exercising a certain muscle group. However, for redevelopment of such an important group as the quadriceps, it is felt that the pulley system is inadequate.

Maintenance of Hypertrophy and Power

The progress of several patients has been followed for ten months after terminating this program of intensive exercise. Measurement at this time revealed no appreciable loss of muscle size or power, and there was no return of the symptoms previously noted,—such as giving way of the knee or weakness of the extremity. The patient can best maintain the power gained by exercising once or twice a week for fifteen to thirty minutes at a time. It is comparatively easy to maintain the power, once it has been attained.

Types of Cases in which Exercises are Used

1. Unstable knees resulting from tears of the cruciate and collateral ligaments.
2. Knees following removal of the menisci—lateral, medial, or both. The program has been used vigorously following total synovectomy of the knee, with good results.
3. Fractured femora.
4. Fractures of the patella.
5. Recurrent dislocation of the patella.
6. Fractures of tibia and fibula where prolonged immobilization has brought about quadriceps atrophy, as well as atrophy in other muscles of the extremity, and limited motion in the knee joint.
7. Knees following chondrectomy for chondromalacia of the patella.
8. Muscle weakness and limitation of joint motion, due to severe soft-tissue wounds and scarring.
9. Removal of foreign bodies from the knee joint.
10. Knees after patellectomy.

The best results have been obtained in cases of unstable knees, meniscectomies, and fractured femora. We believe the exercises are contra-indicated in cases of chondromalacia, in which the disease is accompanied by pain, swelling, and fluid, and where open operation has not been performed.

DISCUSSION OF CASES

Knee Instabilities

The most dramatic results have been obtained in cases of instability of the knee, of which twelve have been subjected to these exercises. In each the ligamentous injuries were old, and had not responded satisfactorily to previous treatment. Three are presented in detail, and serve to illustrate the progress made in most cases. The instabilities varied in nature: nine with injuries to the anterior cruciate and tibial collateral ligaments; one with injury to the tibial collateral ligament, with marked relaxation; one with injury of the anterior and posterior cruciate and tibial collateral ligaments; and one with injury of the anterior and posterior cruciate and fibular collateral ligaments.

The type of injury did not seem to influence the results, inasmuch as rapid gains and alleviation of symptoms occurred in the extremely loose joints as in the less unstable joints. Four of the twelve were wearing Jones knee cages when they began the exercises. Two patients discarded the braces after fourteen days, one after twenty-one days, and another after twenty-three days. In other words, the average time from beginning the exercises to the time when the patients had enough quadriceps power to safely begin ambulation without the brace was eighteen days. Eight of the twelve were able, after from four to six weeks, to run and play ball, without their braces and without "buckling" of the knee. Nine of the twelve had varying degrees of fluid and swelling when exercises were started; in eight of the nine these symptoms disappeared in one to three weeks. In one patient a

slight amount of swelling persisted. Ten of the patients had pain on exercising and weight-bearing initially; seven lost the pain; three did not.

In all cases, after maximum benefit had been derived from the exercises, the instability persisted unchanged when the quadriceps muscle was relaxed. However, when the quadriceps muscle was contracted, it was impossible to demonstrate any looseness about the joint. A powerful quadriceps renders the knee stable only when it is contracted; but,

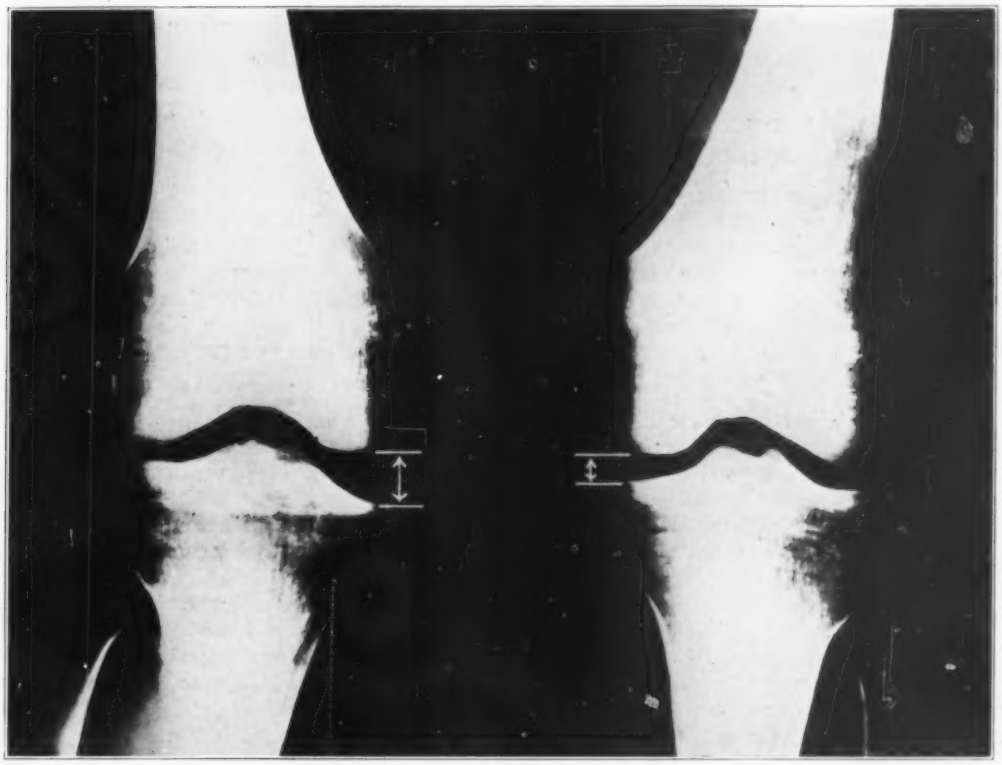


FIG. 6

Roentgenographic studies for tear of the tibial collateral ligament, showing positive abduction spread.

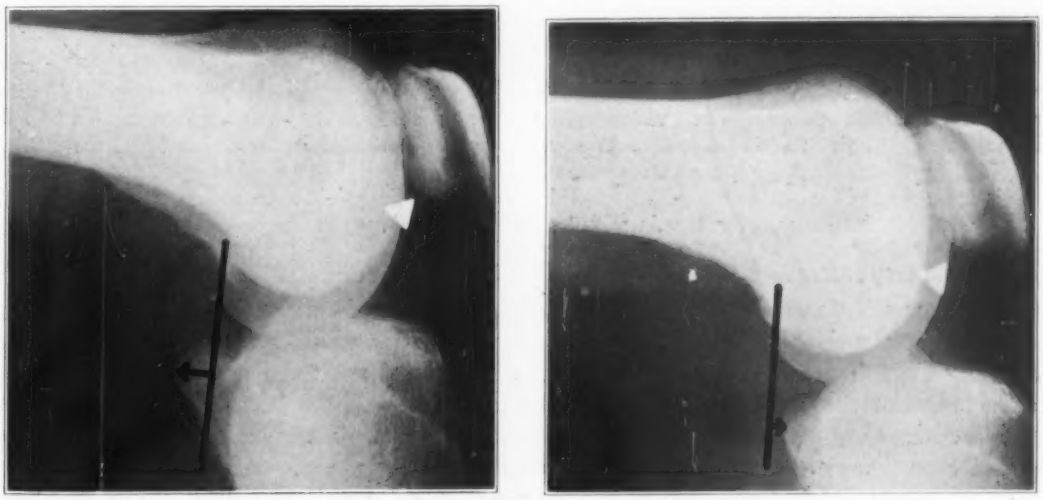


FIG. 7

Positive drawer sign for tear of anterior cruciate ligament.

when contracted, offers sufficient stability for ordinary activities and, as demonstrated by some of our cases, even for rather strenuous sports. It is the purpose of the exercises to build the quadriceps muscle to become powerful enough to maintain the stability of the knee, without the full help of the ligaments. Normal quadriceps power is not sufficient for this, so greater-than-normal power must be built in the involved extremity. This explains why we use such extremely heavy resistance in cases of knee instability. In fractured femora, meniscectomy cases, *et cetera*, where the knee is stable, the purpose is to restore normal power to the injured leg; therefore, redevelopment is not pushed to such an extreme degree.

In none of the twelve cases were there any ill effects from the strenuous program of exercise.

The splendid response of these patients to exercise alone suggests that in certain types of old ligamentous injuries, surgery may not offer more.

An officer sustained an injury of the tibial collateral ligament, following which he was immobilized in a cylindrical plaster cast for seven weeks. After removal of the cast, he received physical therapy for seven weeks before the heavy-resistance exercises were begun. At the time the exercises were begun, he had a marked limp, walked with a cane, complained of pain about the knee, and the knee was slightly swollen. In twenty-one days his knee was completely asymptomatic; he had equal power in both quadriceps muscles; and had gained three-quarters of an inch in circumference of the thigh. His maximum quadriceps power increased from ten to eighty pounds. This patient returned to limited duty with the infantry, with automatic revision to full duty.

A soldier sustained a complete dislocation of the knee when he fell from a four-foot platform. Two weeks after injury, a meniscectomy was performed, and the patient returned to duty, but was unable to continue because of pain on weight-bearing. Five months after the initial injury, another arthrotomy was done, a partial tear of the anterior cruciate ligament being sutured and a fascial flap placed at the site of the tibial collateral ligament. Instability persisted, and, eleven months after the initial injury, a third operation was done, at which time a fascial reconstruction of the tibial collateral and anterior cruciate ligaments was undertaken. Again the instability persisted, and the patient was fitted with a Jones knee cage. Three and one-half months after the last operation, the patient undertook the heavy-resistance exercises. At this time there was atrophy of the thigh of two and one-half inches, flexion of 58 degrees, maximum power of two and one-half pounds, and moderate swelling of the knee joint. In fifty-two days of exercise, the patient made the following gains: a power increase of sixty-two and a quarter pounds in the quadriceps, an increase of two inches in circumference, and a gain of 42 degrees in range of motion. By the end of the third week of exercise, he had discarded the knee cage. Pain and swelling rapidly disappeared. The patient was discharged from the Army because of his knee injury, took a job as a truck driver, and his knee has remained asymptomatic.

Another soldier sustained injury to the tibial collateral and anterior cruciate ligaments while skiing. Figure 6 shows the increase in the medial joint space due to injury of the tibial collateral ligament. Figure 7 shows the positive drawer sign for tear of the anterior cruciate ligament. Following the injury, the patient had pain, thickening, and fluid in the knee. For four and one-half months he had conventional physical therapy, without improvement. After this period, a Jones knee cage was worn. Even with the brace, and while walking on level surfaces, he frequently would fall, because of the instability and muscle weakness. After using the knee cage for seven weeks, he undertook the program of heavy-resistance exercises. Two weeks later, his quadriceps power had increased to such an extent that he felt secure enough to give up his knee cage. The symptoms of pain, fluid, and thickening had completely subsided by this time. After one month of the exercises, the patient had gained one and one-half inches in circumference of the quadriceps, with increased power in that muscle of from twenty to eighty pounds, and he could sprint over uneven terrain at full speed without difficulty.

Meniscectomy Cases

These patients were given quadriceps-setting exercises for several days preoperatively, and the exercises were resumed as soon after operation as possible, usually in twenty-four to forty-eight hours. Quadriceps setting was continued until the synovitis had largely subsided, and the discomfort from weight-bearing was minimal; this required three to four weeks. They were then started on the heavy-resistance exercises, and, with maximum exertion on these exercises, the synovitis continued to disappear.

Twenty patients have exercised postoperatively by the heavy-resistance method. Seventeen of the twenty had definite synovitis of the knee joint at the time exercise was

begun, and in only two of them did the degree of synovitis fail to decrease. In no instance was there exacerbation of synovitis due to the strenuous exercise. No patient was allowed to participate in weight-bearing exercises until the quadriceps power had been restored in the limb operated upon.

The average time required to restore normal power to the affected extremity was nineteen days. Only two of the twenty patients failed to regain normal quadriceps power, and these two developed their quadriceps power to within 80 per cent. of normal. Restoration of normal power and thigh circumference can be expected to occur at a much more rapid rate following meniscectomy than in cases of fractured femur, fractured patella, ligamentous injuries, *et cetera*, where the period of immobilization is usually more prolonged. It must be stressed that, following meniscectomy, the quadriceps-setting exercises given postoperatively are as important as the heavy-resistance exercises in obtaining good end results.

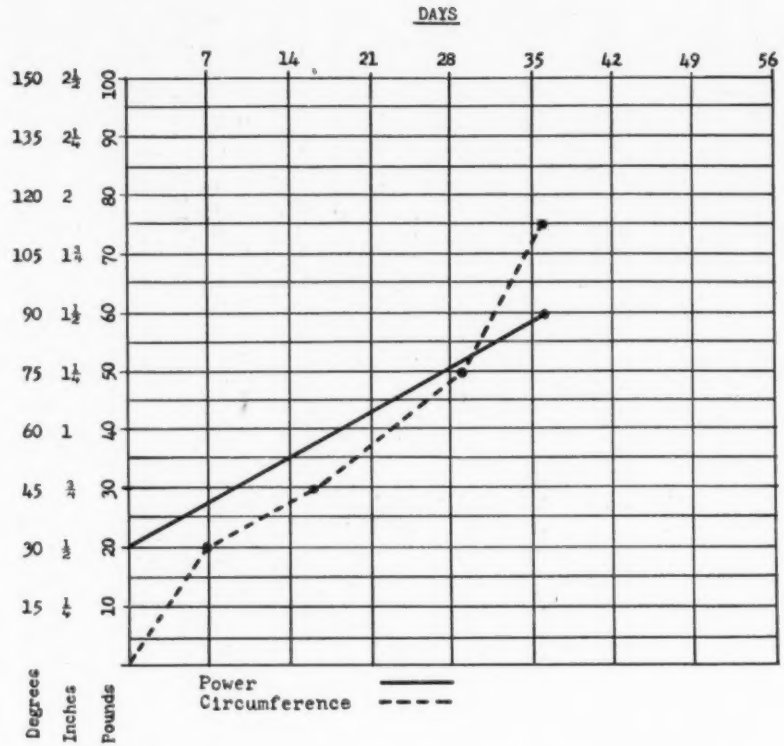
Restoration of a normal range of motion offered no problem in any of the twenty cases. All patients had normal knee-joint motion on completion of the exercise program. A few had difficulty in obtaining the last 15 or 20 degrees of flexion. These, however, responded rapidly to treatment on the leg-exercising apparatus (Fig. 8).

WEIGHT-BEARING AND NON-WEIGHT-BEARING QUADRICEPS EXERCISES

At this point it is appropriate to discuss briefly these two types of exercises. As far as increasing muscle power is concerned, both types have equal possibilities. They differ, however, in the symptoms they produce in knee joints controlled by weak, atrophied muscles.

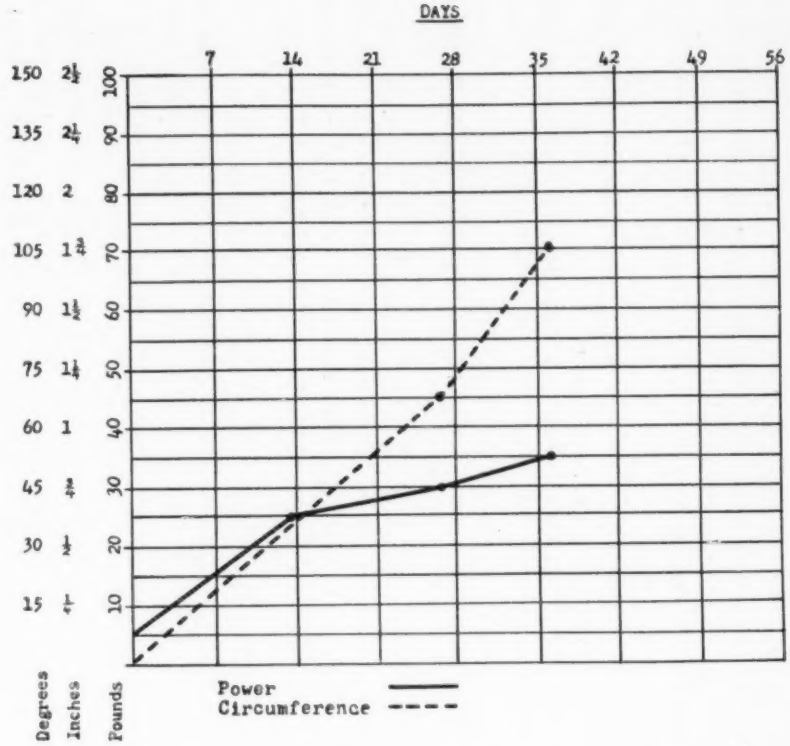
We believe that the development of pain, thickening, and fluid on weight-bearing exercises in many of the cases of meniscectomy and unstable knees is due largely to the increased laxity in the joint, resulting from quadriceps weakness and atrophy. We have seen many of these patients with marked synovitis in the knee joint, in whom complete alleviation of knee symptoms occurred, when quadriceps power was restored to normal by non-weight-bearing, heavy-resistance exercises. The instability results in repeated strains which produce a traumatic synovitis[1] with fluid, thickening, and pain.

Of the twenty patients who had meniscectomies, seventeen had fluid, swelling, or both, of varying degree, when they began these exercises three or four weeks after the operation. On the exercise regimen outlined here, fifteen of the seventeen showed improvement. Of these fifteen patients, eight became completely asymptomatic, both subjectively and objectively; six retained only an insignificant amount of synovial thickening; and one finished the exercise program with a small amount of fluid still present in the joint. This patient had had a meniscus removed from the same knee prior to Army service, following which there developed a chronic synovitis, with marked thickening and induration of the synovia. Before the exercise program was instituted in meniscectomy cases, exercise in the gymnasium was started three or four weeks postoperatively, in an attempt to redevelop quadriceps power in these patients by the conventional methods,—such as stairclimbing and bicycling. On this routine, the hitherto smooth postoperative course of rapidly subsiding synovitis was not only interrupted, but in many cases there was a marked exacerbation of synovitis, which usually subsided as soon as the patient was taken off the weight-bearing exercises. It was then found that, when these same patients were given only non-weight-bearing exercises, synovitis did not recur, and the synovitis, which had previously developed, subsided during the course of exercise. It must be assumed that there is some factor in the weight-bearing exercises that produces synovitis, and that this factor does not exist in the non-weight-bearing exercises. These findings can be explained on the basis of relative knee instability. The quadriceps muscle is as important in maintaining knee stability as are the cruciate and collateral ligaments; and, when this muscle group is atrophied and weak, the maintenance of stability rests almost entirely on the



BEFORE EXERCISE		AFTER 36 DAYS
20 lbs.	Maximum power	60 lbs.
20½"	Thigh measurements	22⅜"
126°	Degree of flexion	135°

CHART I



BEFORE EXERCISE		AFTER 36 DAYS
5 lbs.	Maximum power	35 lbs.
14¼"	Thigh measurements	16"
60°	Degree of flexion	104°

CHART II

ligaments. The ligaments alone cannot maintain as high a degree of stability as when aided by the quadriceps muscle. When, as in cases of meniscectomy, quadriceps power is low, there is abnormal motion in the knee joint. It is this abnormal motion that is indirectly responsible for the development of synovitis in weight-bearing exercises. The twisting, turning, and jarring of the weight-bearing exercises in a relaxed joint probably traumatizes the synovia by nipping and stretching, causing a synovitis; whereas, if the exercises were performed sitting down, the motion in the joint would be in a normal plane, and the knee would not be under the strain of the body weight. Thus instability is precluded as a source of synovial irritation during convalescence.

Fractured Femora

Charts I and II show the gains made by two patients with fracture of the femur, after they had been discharged from general physical therapy. These two represent the average response in twenty cases of fracture of the femur. The gain in circumference for those patients who had obtained flexion of the knee to approximately 90 degrees ranged from one to two inches in the first four weeks of exercise. When flexion was less than a right angle, the gains were not so rapid, since the quadriceps could not be as thoroughly exercised through this limited range. A few patients who worked exceptionally hard increased their thigh measurements by two to two and a half inches in from six to eight weeks.

Frequently, after immobilization, the muscles of the thigh, especially the quadriceps group, are hard in consistency, due to fibrotic changes, which have occurred during the period of inactivity. Immediately after these strenuous exercises have been begun, these same muscles begin to soften, and in a few weeks have regained their normal consistency. This rapid softening of hard fibrotic muscles has been one of the most interesting aspects of this program, and has further substantiated our belief that weakened, fibrotic, atrophic muscles should not be "pampered" because of their subnormal condition, but should be exercised against heavy resistance. In the case of one patient who was immobilized for fourteen months, the thigh muscles of the injured leg showed atrophy of two inches, and had the consistency of hard rubber. After two months of exercise, the thigh had increased one and one-half inches in circumference, and the consistency was that of normal muscle.

Restoration of Motion

Attaining a normal range of knee-joint motion, following immobilization incident to a fracture of the femur, is often a difficult and perplexing problem. After prolonged immobilization, especially in fracture of the lower third (more especially those involving the femoral condyles), there is often a marked limitation of flexion. When some of these patients first begin physical therapy (consisting of heat, massage, and exercises with mild forcing) they often rapidly regain flexion of about 30 to 50 degrees, and then during weeks and months of a similar routine make no further progress. For these cases a leg-exercising apparatus (Fig. 8) has been constructed.

Leg-Exercising Apparatus

This machine was designed to allow the patient to exercise the leg against resistance in a position most conducive to the bending of the leg by such resistance. Because the patient himself is in complete control at all times of the amount of resistance, and can remove and apply resistance as pain and fatigue dictate, he will allow the leg to flex more than if a physical therapist were applying the same amount of resistance by hand. The patient cannot control the pressure or movements of the operator, and will not relax the antagonistic muscles sufficiently to permit the knee to bend to a point of discomfort. However, if he himself can apply the resistance, he will allow the knee to bend to the point of pain, without complaint. In order to attain flexion in stubborn cases, it is necessary to exercise to the point of discomfort, even pain.

The apparatus is used in the following manner: The exercise begins with knees com-

pletely extended (Fig. 9). The pins labeled *A* are removed, thus freeing the weight, which is then slowly lowered, as the knee is allowed to flex. The downward direction is continued as far as pain or tightness in the joint will permit. The knee is then completely extended; there is a momentary pause, and it is lowered again. The cycle is repeated ten to twenty times. The pins are replaced, the patient rests for a minute or so, and the cycle of ten to twenty repetitions is repeated two or three times.

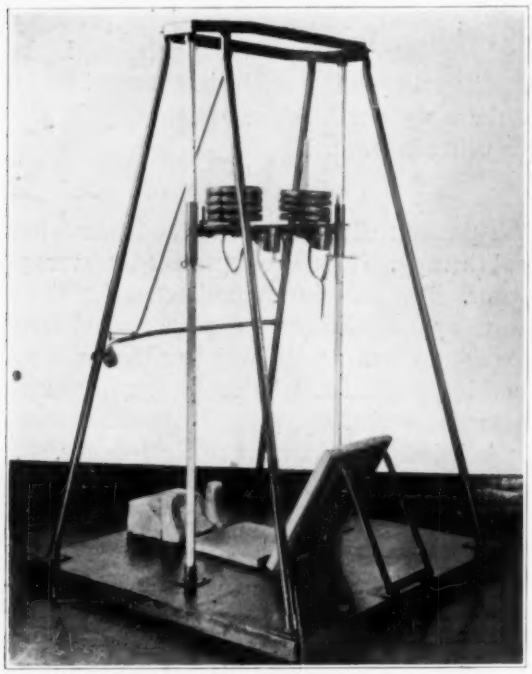


FIG. 8
Leg-exercising apparatus.

Twenty patients with fracture of the femur have been given these exercises on this apparatus. All twenty had been discharged from general physical therapy as having attained maximum flexion. By the use of this apparatus, the average gain in flexion was 25 degrees in thirty-two days. However, these figures include eight patients who had fractures about the femoral condyles or who had had prolonged immobilization because of slow union or refracture. They showed an average gain of 21 degrees in forty-two days. Twelve patients with uncomplicated fracture of the middle and upper thirds showed an average gain of 27 degrees in twenty-one days, a considerably more rapid rate of gain than that of the group first mentioned. Two of the

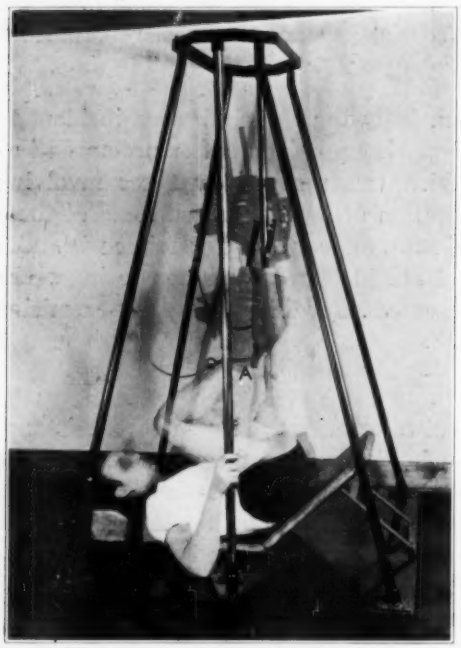


FIG. 9
Leg-exercising apparatus being used to regain flexion. The pins (*A*) fit into the metal guides at different levels, to limit downward motion of the central plate.

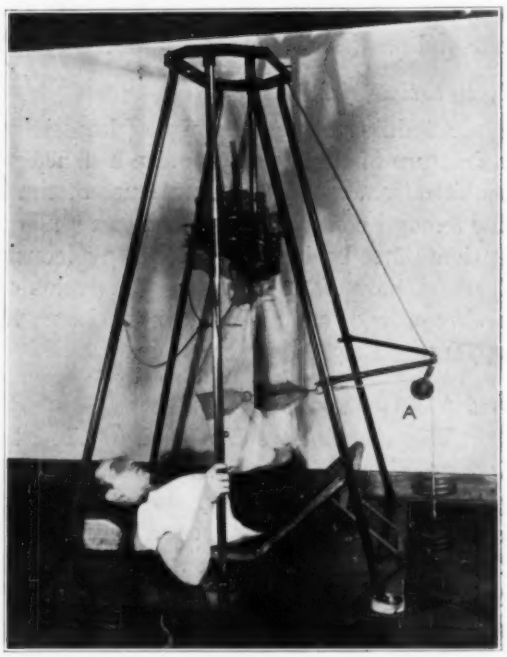


FIG. 10
Leg-exercising apparatus, showing use of the pulley system (*A*) to increase knee-joint extension.

twenty patients were treated by manipulation under anaesthesia in an attempt to increase knee-joint motion; one gained 6 degrees as a result of manipulation; in the other, no increase in flexion could be attained. Both were then placed on this apparatus; the former gained 33 degrees more flexion, the latter 20 degrees. It must be emphasized that the gains in flexion recorded in all twenty cases were made after these patients had received the customary physical therapy for weeks, sometimes months, and had been discharged because no further progress could be made. Constant bending in the form of active heavy-resistance exercises will often produce more flexion than can be accomplished by a single or repeated manipulation. In a few cases, this strenuous flexion of the knee has produced slight swelling of the joint, but in no case has there been effusion. The swelling and soreness which sometimes develop usually subside by the next exercise period.

This apparatus can also be used as a muscle developer with increasing amounts of resistance, after the patient has obtained a good range of motion. When the machine is used for muscle developing alone, the same principle of exercise and method of increasing resistance are used as for the quadriceps exercises. When used for increasing flexion, the amount of weight that can be pushed back into complete extension ten to twenty times with moderate effort is employed.

Three patients who had flexion contractures of the knee rapidly regained complete extension by working on this apparatus. The pulley system (Fig. 10, *A*) brings pressure to bear immediately above the patella by means of the leather cuff. The pressure is directed towards extension. On each repetition, as the knee reaches its maximum extension, the cuff aids the thigh extensors in effecting further extension. Strenuous quadriceps exercises were also given in these cases.

If the injury was a simple fracture of the patella, or if the lower pole of the patella had been removed, the return of motion, strength, and size was usually rapid. However, if the patella was highly comminuted, or if there developed chondromalacia following fracture, the high-resistance exercises usually caused much pain, and occasionally fluid and swelling, and had to be abandoned.

After the immobilization period following dislocation of the patella, these exercises were begun and a rapid return to normal was noted. By building an exceptionally powerful vastus medialis, it might be possible to prevent redislocation of the patella, when the dislocation was due chiefly to weakness of that muscle.

Two patients had chondrectomies for chondromalacia of the patella; following operation, both patients had moderate synovitis of the knee. In each, the synovitis subsided, and smoothing of the patellofemoral articulation occurred as a result of these exercises.

There were many patients with soft-tissue wounds about the knee and thigh. In these, loss of flexion or extension, due to muscular weakness, scarring, or both, was the usual problem. In many cases, where the loss of active motion was a result of muscular weakness, due to loss of muscle substance, the remaining muscle tissue could be overdeveloped sufficiently to compensate for the lost tissue, thereby restoring almost normal strength to the extremity.

Many patients had a limited range of motion because of scarring about the knee joint. Unless bound hopelessly to bone or other deep structure, these scars in most instances underwent remarkable softening, allowing for normal joint motion. The constant flexing in the leg-exercising apparatus (Fig. 8) was sufficient in many cases to restore flexion to normal. The quadriceps exercise usually rapidly restored enough quadriceps power to make possible complete extension.

Results following removal of foreign bodies from the knee were similar to those in the meniscectomy patients, unless there had been considerable joint damage.

In order to gain full extension following patellectomy, it is essential to have a powerful quadriceps. We have used this program of heavy-resistance exercises in only two of these cases. The patients rapidly obtained complete extension, without development of

FIG. 11
Adductor exercise.

FIG. 12
Abductor exercise.

synovitis; and quadriceps power was restored to within 90 per cent. of that in the unaffected extremity.

When quadriceps power has increased sufficiently to permit weight-bearing exercises, the patient is given heavy-resistance exercises for the other muscles of the extremity.

DEVELOPMENT OF OTHER MUSCLES OF BODY BY SAME EXERCISE PRINCIPLE

The following are some of the other exercises we have used in redeveloping other muscles of the body by the same principle. The type of apparatus, however, varies consid-

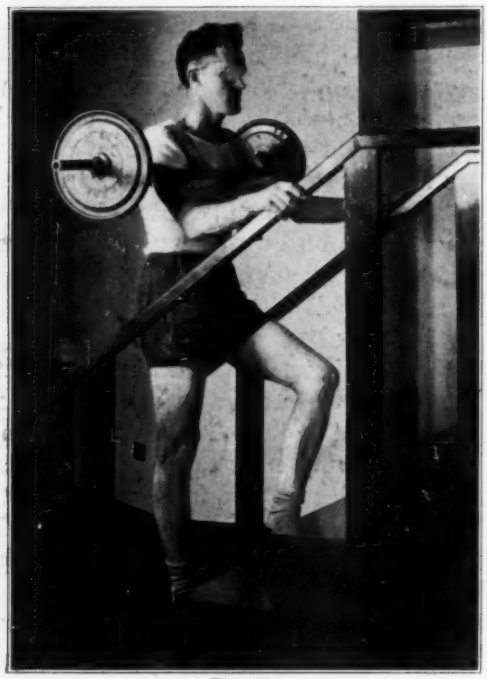


FIG. 13
Stairclimbing exercise.

FIG. 14
Ankle exercise. Resistance can be added at points *A*, *B*, *C*, and *D*, thus giving resistance in dorsiflexion, plantar flexion, eversion, and inversion, respectively. This apparatus has 180 degrees of motion in all four directions, thus also making possible rotary ankle motion.

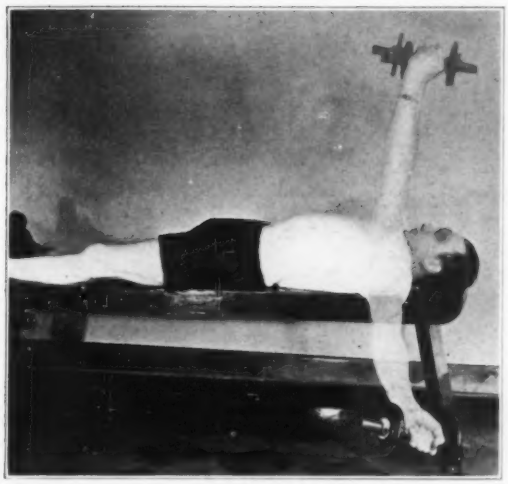


FIG. 15
Pectoral exercise. Arms may be kept straight or slightly bent at the elbow.

FIG. 16
Supine press.

erably, and is designed specifically to obtain the desired results. The repetitions, method of weight increase, frequency and length of workout are exactly the same as described for the quadriceps exercises.

I. *Lower Extremity*

A. *Adductor Exercise.* This exercise is shown in Figure 11.

B. *Abductor Exercise.* See Figure 12.

C. *Hamstring Exercise.* This is an extremely important exercise, and should be diligently performed, especially by patients attempting to regain flexion in stiff knees.

D. *Stairclimbing Exercise.* This exercise is not used to develop the quadriceps; it is not used at all, until the patient has built nearly full quadriceps power by the use of previously described quadriceps exercise. Resistance is added to a metal yoke, and the patient goes over and back five times with one weight, rests a minute or so, adds more weight, and then repeats. By use of the yoke, the hands are free to grasp the rail (Fig. 13). This exercise was thought necessary because, even though a patient may have good quadriceps power, he may still have some difficulty in stairclimbing, if all the other muscles involved are not proportionately developed. The exercise develops, in the low-repetition, high-resistance manner, all of the muscles involved in stairclimbing.

FIG. 17
Shoulder-pulley exercise.

E. *Calf Exercise.* The resistance in this exercise is applied by adding weight to the yoke. The use of the yoke permits the hands to remain free, and the patient can use his hands to steady himself, and maintain balance by grasping a bar in front of him. As strength increases, more weight can be added; and, as ankle-joint motion increases, the wooden block can be made higher.

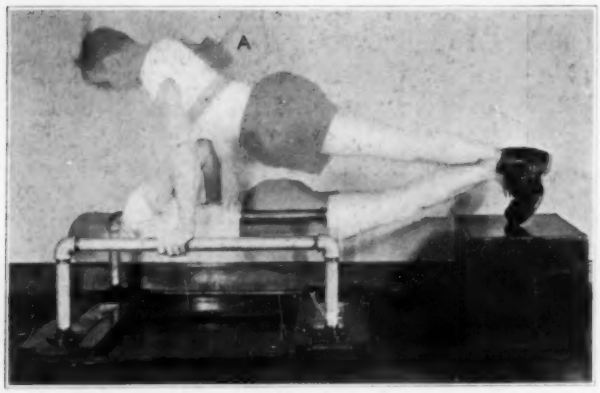


FIG. 18

Parallel bars. Resistance is added to the weight pan (*A*), strapped to the patient's back. The bars can be slid further apart as power and motion increase.

F. *Ankle Exercise.* The apparatus shown in Figure 14 was devised to exercise the ankle in both dorsiflexion and plantar flexion, in eversion and inversion. Resistance may be added to the hook at *A*, *B*, *C*, or *D*. The apparatus is also used to help restore ankle-joint motion.

II. *Arm and Shoulder*

A. *Pectoral Exercise.* Amazing hypertrophy of the pectoral muscles can be attained in two or three weeks through the practice of this exercise (Fig. 15). Two patients, who sustained machine-gun-bullet wounds through the axilla with resultant damage to the pectoralis major and limitation of abduction because of scar tissue, were able to loosen the scar sufficiently to obtain a complete range of shoulder motion by use of this exercise. In both cases, after a month of exercise, the patients had increased the size of the atrophied pectoralis so that it was larger than the corresponding uninjured muscle.

B. *Deltoid Exercise.* This is well known.

C. *Biceps Exercise.* This is an important exercise, as there exists usually an inch or so of atrophy of the arm following immobilization for fracture of the humerus. It is important, not only because it redevelops biceps power, but also because of its value in increasing elbow-joint motion. We believe that exercising for biceps power will do more to restore elbow-joint motion than all efforts to increase motion of that joint while neglecting biceps power. In this we must except instances where there is a mechanical block or where severe irreparable capsular and pericapsular changes have occurred. On each

FIG. 19

Exercise for external rotators of the arm. The pronator and supinator muscles of the forearm are exercised on the attachment labeled *A*, to which resistance is applied on the weight pan *B*. Resistance for the shoulder exercise is applied to the weight pan *C*.

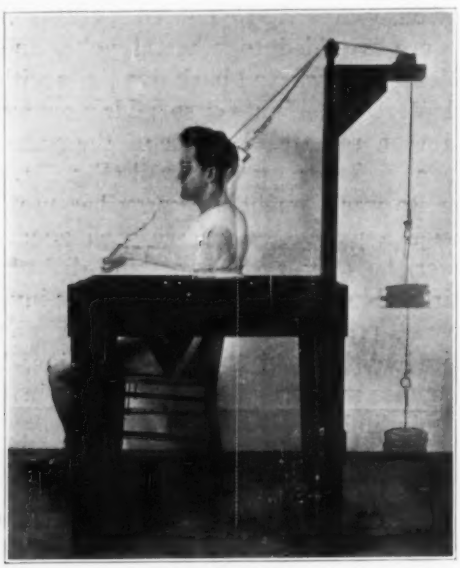


FIG. 20

Exercise for internal rotators of the arm.

repetition the patient should make every effort to obtain as much flexion and extension as possible. Triceps exercises should also be used in conjunction with the biceps exercise.

D. *Supine Press.* See Figure 16 for illustration of the exercise. This is extremely good for loosening up the elbow and shoulder joint.

E. *Pulley Exercise.* Restoring normal scapulohumeral motion following a fracture of the humerus is often difficult. We have obtained, in most instances, good results through use of this pulley exercise, combined with the pectoral, biceps, and deltoid exercises. It is essential that the pulley be an extremely high one, so that the arm can go into complete abduction (Fig. 17). On each repetition the arm should be allowed to abduct as far as comfort will permit the weights to pull it; then the arm is brought back to the side, there is a momentary pause, and the exercise is repeated. This is done ten times, more weight is added, and it is repeated another ten times, *et cetera.* An effort should be made to abduct the arm a fraction further on each repetition. This exercise has produced good results, where scapular motion is limited because of fractures of the scapula and large soft-tissue defects. The constant forcing, in the form of active, heavy-resistance exercises, steadily increases the motion of the joint.

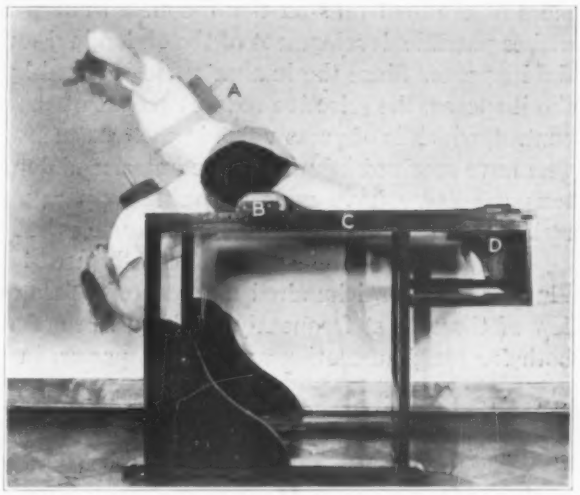


FIG. 21

Hyperextension exercise being performed on special back exerciser. Resistance is increased by adding weights to the weight pan *A*. The body rest *B* is adjustable on track *C* to accommodate an individual of any height. The feet are securely immobilized in two iron boots *D* attached to the frame.

FIG. 22

Abdominal exercise.

F. *Parallel Bars.* This is a good exercise for the shoulder and arm (Fig. 18). Resistance is added to the weight pan strapped to the back. The width of the bars can also be varied.

G. *Arm-Exercising Table.* This table is designed to exercise the pronators and supinators of the forearm, and the external (Fig. 19) and internal (Fig. 20) rotators of the shoulder.

III. *Trunk*

A. *Back Exercise.* Hyperextension exercises are done on the apparatus shown in Figure 21. This apparatus offers several improvements over the method in general use. The weight pan attached to the back makes possible increases in accurately graded resistance. This cannot be accomplished, as was attempted in the old method, by progressively extending the patient farther over the table edge. Our method does not require an operator to hold the patient's feet. The position of the patient is more stable and comfortable; and, since he is not quite parallel to the floor, it is much easier for him to hyperextend more completely.

B. *Abdominal Exercise.* By maintaining the knees and hips flexed (Fig. 22),

more of the load falls on the abdominal muscles and less on the iliopsoas muscle. This makes possible development of the abdominal muscles without concurrent development of the iliopsoas. Since the lumbar spine is flexed by the abdominal muscles and extended by the iliopsoas, the selective redevelopment of the abdominals brings about stronger pelvic control, which is of great value in the treatment of certain back ailments. Many patients who have received injuries to the anterior abdominal wall, with resultant loss of muscle tone and tissue, have exercised on this apparatus with considerable improvement. Graded resistance increases are made by increasing the incline of the board.

Only a few of the exercises actually used have been mentioned. With the equipment illustrated, several hundred different exercises can be worked out. We have shown only a few of those most frequently used, but, in order to conduct exercise programs properly, both for range of motion and muscle power, in a great variety of injuries, a therapeutic gymnasium must be equipped with the apparatus described.

THE THERAPEUTIC GYMNASIUM

The therapeutic gymnasium should not be a place of amusement or for keeping fit. It should be a place in which a treatment, prescribed after thorough examination by the medical officer, can be properly given. The gymnasium should be supervised by the medical officer, but it is not necessary that he actually attend the exercises. The gymnasium should be planned and constructed as specifically for its purpose as is the operating room for its purpose. All pieces of exercise apparatus should be designed to produce a desired result in a specific type of case. Accurate notes on the progress of each patient should be made at regular intervals. The patient should work by appointment, and his attendance should be recorded. The appearance of the gymnasium and the working condition of the equipment are very important, for the patient will maintain much more interest in his exercise if the gymnasium is bright, colorful, well ventilated, and well kept. Equipment in poor condition is not only dangerous, but it also disheartens the patient, and makes it difficult for him to perform his exercises.

It is a good policy to work out several different ways of doing the same exercise. This will prevent the patient's losing interest from monotony. The greater the variety of exercises, the greater the patient's interest.

It has been our experience that greater cooperation is achieved, when the patient understands the nature of his injury. Anatomical charts are kept, and are exhibited on the walls, to give him a clear conception of his disability and its location. He also can see what muscles have to be redeveloped or what joints must be loosened up, before he can attain maximum benefits. A chart with the normal ranges of motion for all the joints of the body should be displayed, and the patient should be taught the normal range of the joint upon which he is working. He should become familiar with the measurements of his affected part, the power of that part, and the exact number of degrees of motion present; then, each week, when new measurements are taken, he will know in inches, degrees, and pounds the gains he has made. This will do much toward maintaining the patient's interest.

The instructor should be efficient, thoroughly familiar with each patient's disability, know what he is trying to accomplish in that patient and, above all, display interest in the work. A patient cannot be expected to show any more enthusiasm than the one who supervises his exercise.

CONCLUSIONS

1. Low-repetition, high-resistance exercises produce power.
2. High-repetition, low-resistance exercises produce endurance.
3. Each of these two types of exercise is incapable of producing results obtained by the other.
4. Weakened, atrophied muscles should not be subjected to endurance-building exercises, until the muscle power has been restored to normal by power-building exercises.

5. Restoration of muscle power with return of motion in a limb has been neglected in the past. It is, in most instances, preferable to have a limited range of motion with good power than a normal range of motion with inadequate power.

6. Games and group exercises, as practised in reconditioning programs, are unsatisfactory for producing focal muscle development.

7. In order to obtain rapid hypertrophy in weakened, atrophied muscle, the muscle should be subjected to strenuous exercise and, at regular intervals, to the point of maximum exertion.

8. In cases of meniscectomies and unstable knees, quadriceps power should be obtained by the use of strenuous, non-weight-bearing exercises. Weight-bearing exercises can produce pain, thickening, and fluid in knees, which do not have adequate muscle support.

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POLYMORPHOUS-CELL SARCOMA, THE MALIGNANT PHASE OF GIANT-FOLLICLE LYMPHOMA, WITH GENERALIZED SKELETAL INVOLVEMENT AND MULTIPLE PATHOLOGICAL FRACTURES

Report of a Case

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INTRODUCTION

In 1925 Brill, Baehr, and Rosenthal described a disease entity which was characterized by splenomegaly and generalized lymphadenopathy. The pathological change was one of qualitative and quantitative hyperplasia of the follicles of lymphoid tissue to such an extent that it was called giant-lymph-follicle hyperplasia. This observation was confirmed by Symmers [8] who recognized other instances of the disease. Later, Baker added a case.

Further studies of cases of giant-follicle hyperplasia [1] revealed that the tumor could undergo a malignant transformation, and Symmers [9] has discussed the relation of such a malignant phase to Hodgkin's disease and lymphatic leukaemia. The clinical and pathological features of the disease have been summarized by Baehr,[2] and the roentgen treatment of the tumor has been emphasized by Rosenthal, Harris, and Kean, and by Rubenfeld. The association of giant-follicle lymphadenopathy with various skin lesions was presented by Combes and Bluefarb.

In only one case in the literature, however, was a single pathological fracture encountered. Little mention is made of the ability of polymorphous-cell sarcoma to invade bone. The case about to be reported is of interest from several standpoints. There were at least seven pathological fractures, and the entire skeleton was involved. Numerous laboratory procedures were carried out. The diagnosis was supported by biopsy as well as by autopsy, which revealed changes in the tumor from site to site, so that in different microscopic sections it resembled Hodgkin's disease, reticulum-cell sarcoma, polymorphous-cell sarcoma, and giant-follicle hyperplasia.

CASE REPORT

A. F. (No. B34548), a white woman, seventy-seven years old, was admitted to the New Haven Hospital for the first time on October 17, 1942, and discharged on October 24, 1942. At that time a diagnosis of pathological supracondylar fracture of the right humerus was made. The roentgenograms showed the appearance of metastatic tumor with diffuse skeletal involvement (Fig. 1). Search for the primary site was unsuccessful.

The second admission to the Hospital was on April 22, 1943. At this time the patient had sustained a fracture of the shaft of the left femur by turning over in bed.

The past history revealed that there had been a hard tumor mass on the forehead in the mid-line for the last seven years. This had not been increasing in size. For the last three years swellings in the region of each parotid gland had been noted, but according to the history obtained these had not been increasing in size.

The family history was of interest only in that a sister of the patient was reported to be dying from a cancer of the breast.

On physical examination the essential features, in addition to the fracture of the shaft of the left femur, were those of a hard, conical, regular, mid-line protuberance on the forehead, measuring three centimeters in diameter at its base, and bilateral tumors in the region of the parotid glands, which were firm, irregular, and freely movable, and about four centimeters in diameter. There were some small palpable lymph nodes in the posterior triangles of the neck. These were so small that not much importance was attached to them at that time.

The fractured extremity was placed in Russell traction. Roentgenograms revealed that the basis

FIG. 1

Pathological supracondylar fracture of the right humerus. Note the destructive process present in the humerus, and particularly in the ulna.

FIG. 2

The healed fracture shown in Fig. 1. Note the progression of the lesion.

FIG. 3

Pathological fracture of the shaft of the left femur. A similar process to that seen in Fig. 1 is apparent.

FIG. 4

The shaft of the left femur, showing the four fractures in various stages of healing.

TABLE I
CHEMICAL ANALYSES OF BLOOD SERUM

Date	Calcium (*Milligrams per cent.*)	Phosphorus (*Milligrams per cent.*)	Total Protein (*Grams*)	Albumin (*Grams*)	Globulin (*Grams*)
Apr. 28, 1943	9.37	4.25	5.18	3.49	1.69
Aug. 9, 1943	10.11	4.42	5.34	3.58	1.76
Aug. 16, 1943	9.8	4.30	5.42	3.66	1.76
Sept. 22, 1943	9.77	4.38	5.23	3.55	1.68

for the fracture was an extensive lesion of the shaft (Fig. 3). The entire skeleton was x-rayed, and every bone was found to be involved with the same destructive disease. It was noted that there were healed fractures of the right humerus (Fig. 2), the left radius, and the second lumbar vertebra.

As the first fracture of the left femur healed, there occurred a second pathological fracture well distal to it, because of an increase in the destructive process. During the healing of the second fracture, a third one occurred in between the first and the second, without any undue or unusual trauma, and while the patient was still in traction. The third fracture healed, and a fourth pathological fracture of the same femur occurred while the patient was attempting to sit up (Fig. 4).

Table I shows the values of the serum calcium, phosphorus, the total protein, and the albumin and globulin fractions on repeated examinations. Vitamin D and calcium lactate, given during the period August 11 to November 21, 1943, had no effect on these figures.

A provocative test for the possibility of hyperparathyroidism was carried out, and yielded negative results.

The serum lipoids were normal. The serum acid phosphatase was 1.5 King Armstrong units (normal: 0.5–2.5), and the serum alkaline phosphatase was 7.7 King Armstrong units (normal: 3.7–13.1). Repeated serological tests for syphilis (Kahn and Wassermann) were negative.

Many examinations for Bence-Jones proteinuria were negative.

The blood picture showed a moderate hypochromic anaemia, with a relatively normal differential count (Table II).

TABLE II
BLOOD FINDINGS

Date	R.B.C. (*Millions per cubic millimeter*)	Hemoglobin (*Grams per 100 cubic centimeters*)	W.B.C. (*Thousands per cubic millimeter*)	Polymorphonuclear Neutrophils Non-Segmented (*Per cent.*)	Polymorphonuclear Neutrophils Segmented (*Per cent.*)	Lymphocytes (*Per cent.*)	Mononuclears (*Per cent.*)	Eosinophils (*Per cent.*)	Metamyelocytes (*Per cent.*)	Basophils (*Per cent.*)
Apr. 22, 1943	3.8	11.2	4.3	18	71	9	1	0	1	0
May 29, 1943	3.5	11.5	8.1	3	69	18	6	3		1
June 22, 1943	3.5	9.5	7.9	9	65	23	3	0		0
Oct. 6, 1943	3.25	9.0	6.1	0	72	22	2	2		2

The non-protein nitrogen was twenty-six milligrams per 100 cubic centimeters, and the phenolsulfonphthalein excretion was 75 per cent. in two hours.

During the patient's stay in the Hospital, there was a gradual enlargement of the nodes in the posterior triangles of the neck, as well as of the bilateral tumors in the parotid regions. The conical protuberance on the forehead also increased in size. The spleen and the liver were not palpable, and there was no other enlargement of lymph nodes.

Biopsy of two cervical nodes was carried out. In each there was the characteristic picture of giant-follicle hyperplasia (Fig. 6). Mitoses were seen, and in one area a tendency to invade the capsule was observed.

Biopsy was done on the olecranon, but this showed only thinning of the cortex and some fibrosis of the marrow. Therefore, a second biopsy of bone was carried out, this time in the distal portion of the ulna, a region shown by the roentgenogram to have had marked destruction. This revealed microscopically no more than the section from the olecranon.

The patient had a gradual downhill course, and died before the fourth fracture of the femur had healed.

The essential findings at autopsy were as follows: Lymph nodes were enlarged in the mediastinum, the neck, the peripancreatic region, and the mesentery. The lymphoid structures of the wall of the gastro-intestinal tract (particularly the stomach, ileum, and colon) were also enlarged (Fig. 7). Tumor had infiltrated the pancreas, but both the liver and the spleen were spared. Examination of the cranium revealed that the conical protuberance was composed of tissue which extended inward to involve the dura, but which spared the brain. All of the bones examined were extensively destroyed by the neoplasm.

FIG. 5
The skull illustrates the same process.

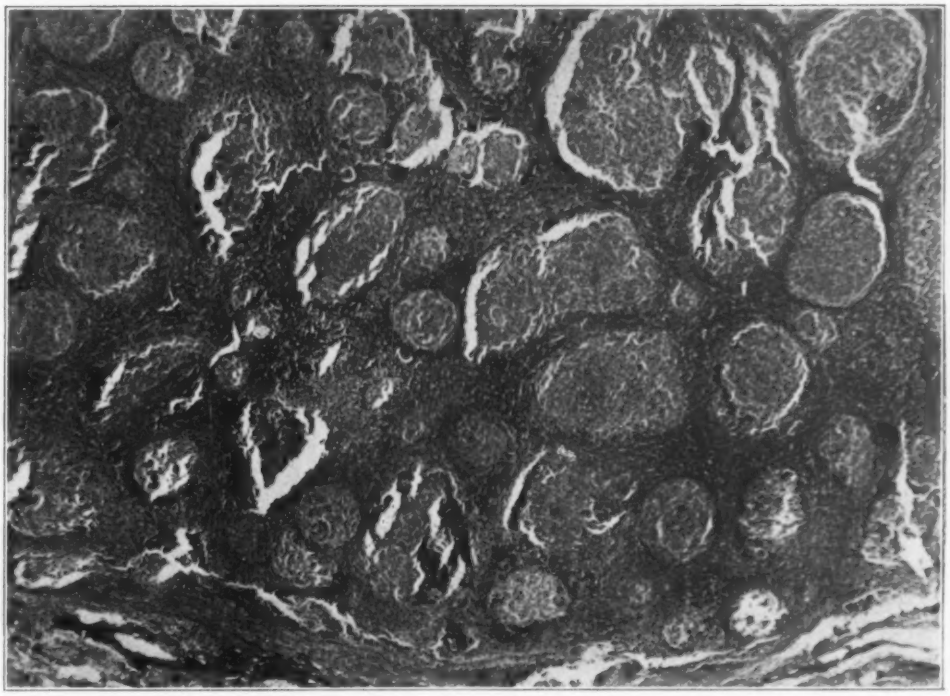

FIG. 6
Section of cervical lymph node with giant-follicle hyperplasia.

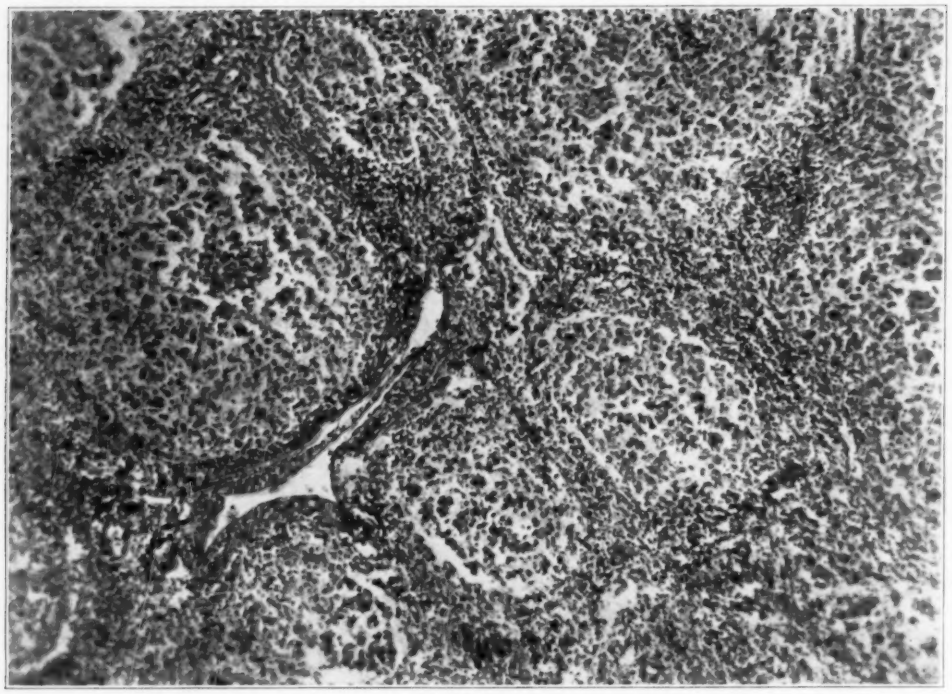

FIG. 7

Section of lymphoid tissue from wall of the stomach. This resembles giant-follicle hyperplasia. Compare with Fig. 8.

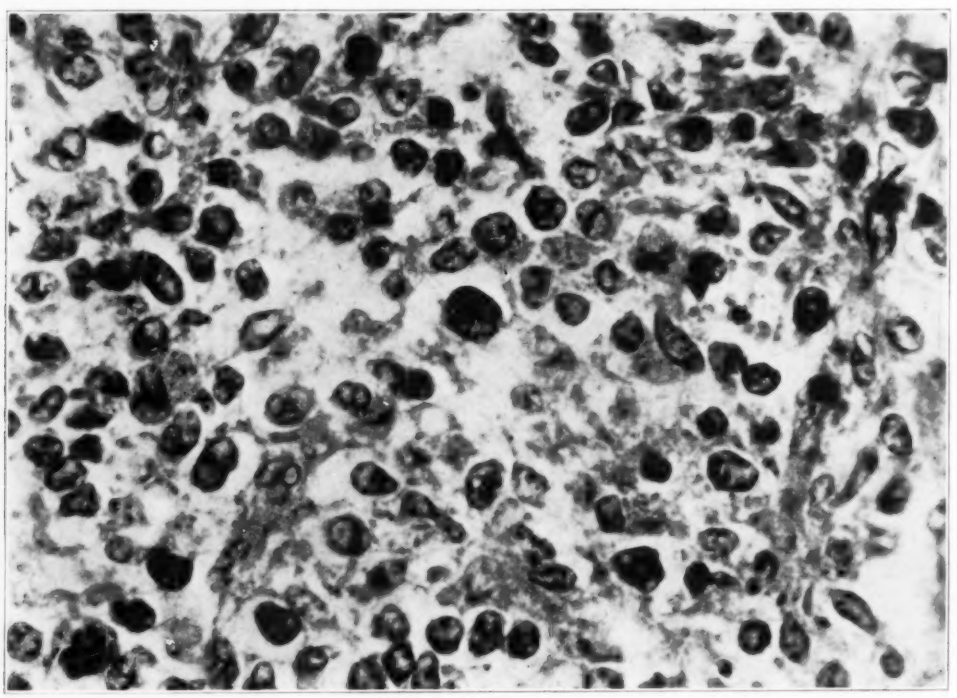

FIG. 8

Section taken from the tumor invading the pancreas. This illustrates the great pleomorphism of the cells.

The microscopic features of the tumor varied in different parts of the body so that various sections examined resembled giant-lymph-follicle hyperplasia, Hodgkin's disease, reticulum-cell sarcoma, and polymorphous-cell sarcoma (Fig. 8).

COMMENT

There were several unusual features in this case. The age was greater than in other cases reported. All bones were invaded. The presenting complaint was a pathological fracture, rather than enlarged lymph nodes. Neither the spleen nor the liver was involved. The tumor presented a histological picture, the predominant characteristics of which varied with the different tissues examined. Numerous laboratory procedures were remarkable for their normal results.

Acknowledgement is gratefully made to H. S. N. Green, M.D., for interpretation of the biopsy, and to Stanley H. Durlacher, M.D., for the autopsy material. Both are members of the Department of Pathology, Yale University School of Medicine.

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SPONTANEOUS BILATERAL FRACTURE OF THE NECK OF THE FEMUR FOLLOWING IRRADIATION

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Numerous cases of fracture of the neck of the femur following irradiation have been reported in the literature. However, since some of these have been associated with trauma, not all can be attributed solely to the effects of irradiation.

It appears that bony union following these irradiation fractures has been rare. Since there are no detailed reports as to the treatment of such fractures, we cannot reach conclusions as to the cause of non-union. It has been suggested that an obliterative endarteritis caused by irradiation was a predisposing factor to non-union, but inaccurate reduction and incomplete fixation may have been the determining causes.

In each of the fourteen cases reported by Dalby, Jacox, and Miller, pain antedated the diagnosis of fracture by some months, with an average of seven months elapsing from the onset of symptoms until fracture was demonstrated; and, in all but one case, roentgenograms of the femur preceded the diagnosis of fracture by months or years. Fracture of one hip in the case reported by Barden did not occur until two years after irradiation, but it is not clear whether the patient had had pain previously. There is no mention in the cases reported as to whether pain was relieved by fixation of the fracture. It is of especial interest to note that in none of the cases of Dalby, Jacox, and Miller had there been direct irradiation over the femoral necks, nor were lateral portals used over the trochanters.

In 1926, Ewing described five stages of the effect of irradiation on bones. These stages progressed from a reduction of vitality and growth capacity of bone cells and bone-forming function, following moderate irradiation, to a complete necrosis with a long delay in sequestration, following severe exposure. There may be an increased fragility and marked tendency to spontaneous fracture, but under favorable conditions such fractures may slowly heal. Ewing attributes these features to the results of injury and sclerosis of blood and lymph vessels.

FIG. 1-A FIG. 1-B

Roentgenograms of the right and left hips on November 11, 1943. There is no demonstrable abnormality at either hip. Patient had been having pain at the right hip for four weeks, beginning fourteen months after irradiation. She did not complain of the left hip.

The following is a report of such a case:

Mrs. Z, sixty years old, was first examined on November 11, 1943. She was complaining of pain at the inner aspect of the right thigh and knee. This had begun four weeks previously, following a long trip on a bus. There was no history of injury or date of acute onset of pain. During June, July, and August, 1942, she had received radium and x-ray treatments for a partially differentiated squamous-cell carcinoma of the cervix. On June 6, 1942, she had received radium treatment consisting of 5076 milligrams and millicurie hours, 2700 hours being given to the uterine canal, and 2376 to the cervix. She had also received daily x-ray treatments from July 6 to August 10, 1942, consisting of 2200 roentgen units, measured in air, to each of six pelvic fields (four lower abdominal and two lateral fields), delivering 3432 tissue roentgen units to the center of the pelvis, using 200 kilovolts and a Thoreaus filter, at a distance of seventy centimeters, to fields fifteen by ten centimeters.

Although the patient limped, she was able to walk without support. There was a moderate muscle spasm at the hip, with limited and painful abduction and internal rotation, and a loss of complete extension. There was no definite tenderness. The physical findings were those present in an early aseptic necrosis of the head of the femur, or the so-called malum coxae senilis. Roentgenograms of the hips, however, showed no abnormality (Fig. 1). She was advised to limit her physical activities and to return for further observation.

The patient was again examined on January 29, 1944, approximately eleven weeks later. Pain had become more severe, and muscle spasm was more pronounced. There was now moderate tenderness over the posterior aspect of the hip. The lower extremity, however, was not everted, and she could raise the straight leg from the table without difficulty, although there was some pain. Fracture was not suspected. She was referred to the hospital for bed rest and traction. Roentgenograms made there on February 18, 1944, revealed a fracture of the neck of the femur with a calcified band of callus and moderate rotation of the head (Fig. 2). There were small and localized areas of rarefaction of bone at the superior portion of the neck of the femur, but otherwise the density of the bone was normal, and not suggestive of aseptic necrosis. Metastatic carcinoma was seriously considered. However, local examination of the pelvic organs and general examination, including roentgenograms of the chest, revealed no evidence of tumor. Therefore, it was thought that the most likely possibility was a spontaneous fracture following irradiation.

Under general anaesthesia, a Smith-Petersen nail was inserted on February 22, 1944, without manipulation of the hip. Following this, the patient was promptly relieved of pain and muscle spasm. She was discharged from the hospital on the twelfth postoperative day, with instructions to avoid weight-bearing, and to begin gentle active exercises of the hip. She was having no difficulty with the left hip.

FIG. 2

Roentgenogram on February 18, 1944, showing fracture of the neck of the right femur. Patient still did not complain of the left hip.

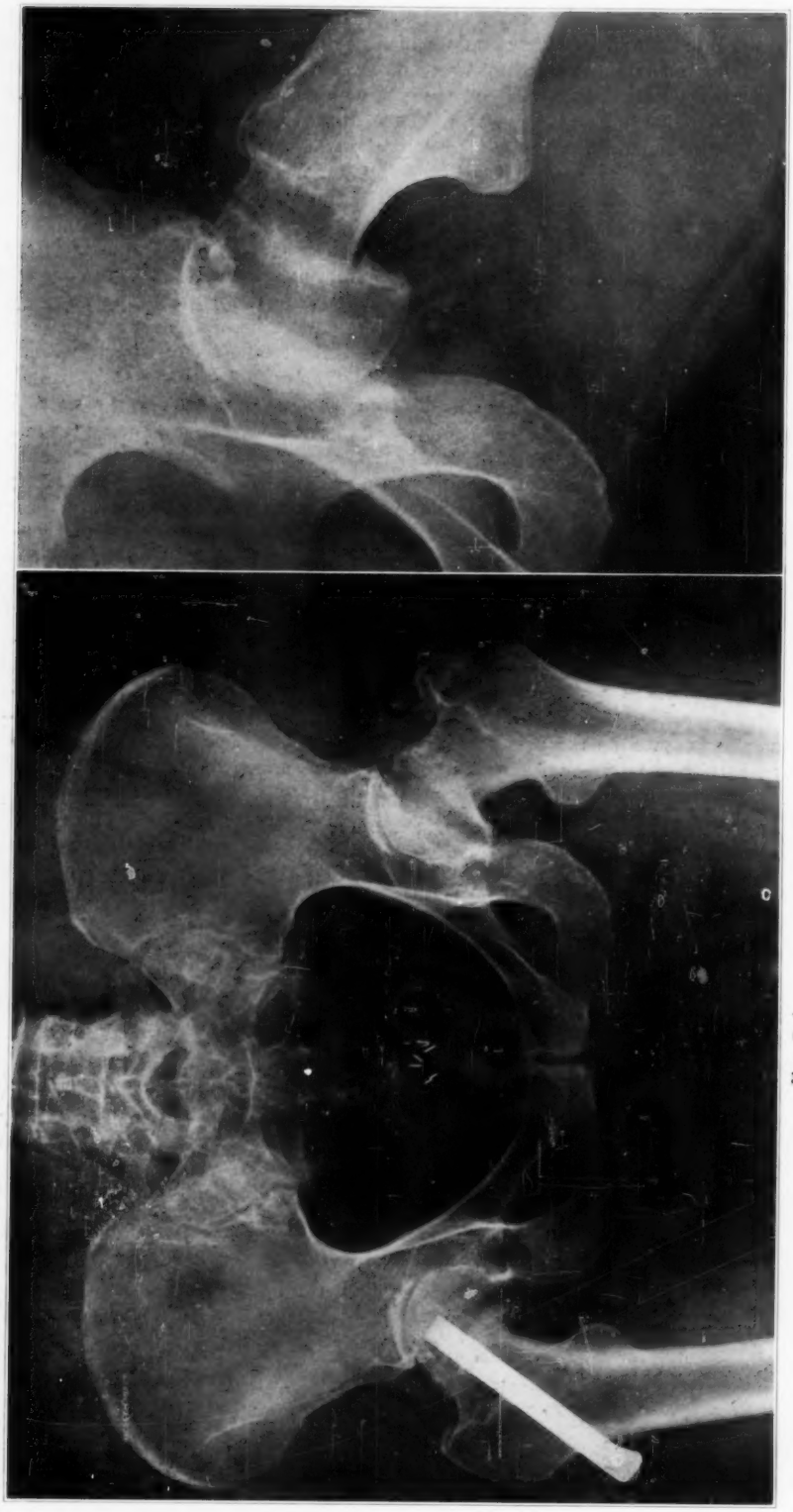

FIG. 3-A

FIG. 3-B

Anteroposterior roentgenograms of both hips and lateral view of left hip on June 24, 1944, six weeks after the onset of pain, showing a fracture of the neck of the left femur. The right hip was then free from pain.

Three months later she complained of pain at the left hip. The onset had been gradual, and there had been no injury. She was walking with the support of a cane, and was bearing most of her weight on the previously nailed hip, which was now painless. There was muscle spasm at the left hip, and inability to raise the straight leg from the table. Roentgenograms showed a fracture across the neck of the left femur, strikingly similar to that at the right hip (Fig. 3). Since prompt relief of pain had followed nailing of the right hip, and union appeared to be progressing, the left hip was also nailed. This was done under general anaesthesia without manipulation, and again there was prompt relief from pain and muscle spasm.

When last seen, in March 1945, the patient was free from complaint. She had no limp, and had normal motion in both hips, except for slightly limited internal rotation. She was quite active, could bear full weight without support, and was doing her own housework.

FIG. 4-A

FIG. 4-B FIG. 4-C

Anteroposterior and lateral roentgenograms of both hips on December 7, 1944. There was bony union, and the patient had no complaint at either hip.

DISCUSSION

This case apparently typifies the features of spontaneous fracture of the neck of the femur following irradiation. Symptoms did not occur at one hip until fourteen months after the completion of irradiation, and at the other hip until eighteen months afterward. Pain was present in each hip at least four weeks before roentgenographic changes were demonstrable. It does not seem likely, in the face of negative roentgenograms during the early period of disabling symptoms, that fracture was the determining cause of pain. On the other hand, the patient was promptly relieved following fixation by means of a nail. This presents a similarity to the poorly understood mechanism of the "march", or "insufficiency", or "exhaustion" fracture of the metatarsal bone, os calcis, or neck of the femur. It is characteristic of these fractures that there is no specific trauma, and that early roentgenograms are negative. Fracture is demonstrable only in later stages, when the nature of the condition is revealed by a band of callus or absorption of bone along the line of fracture.

While it is yet too soon to predict the end result regarding later degenerative changes of the head of the femur, it appears at this time that bony union has progressed normally. Since it is said that non-union is the rule in this type of fracture, it is all the more important that it be treated just as promptly and efficiently as any other fracture of the neck of the femur. Perhaps the likelihood of non-union would then be lessened.

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DISLOCATIONS OF THE CERVICAL SPINE TREATED BY OPEN REDUCTION

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The following report deals with the successful treatment by open reduction of three cases of unreduced fracture-dislocation. In each case, attempted reduction by non-operative methods had failed. In two cases the cause of injury was a motor-transport accident; each patient had been thrown out of a vehicle and landed on his head. In the third case the patient had dived into shallow water.

In the first case there was a unilateral dislocation of the sixth cervical vertebra; in the second, a unilateral dislocation of the third cervical vertebra; and in the third, a bilateral dislocation of the fifth cervical vertebra. Symptoms of cord and root pressure were found in only the first case, the patient having paraesthesia of the upper limbs, and subjective weakness of the right arm and leg. The patients arrived at this Centre from four to sixteen days after injury; attempts at manual reduction had already been made within a few hours after the injury.

In the first two cases further attempts were made at manual reduction under roentgenographic control, with general anaesthesia, but they were unsuccessful. Skull-traction calipers were then applied, and the patient was returned to the ward with initial traction of from ten to fifteen pounds. This was gradually increased to thirty-five pounds, and daily roentgenograms were taken in order to check progress. When it became apparent, after eight to twelve days, that reduction by simple traction was not possible, open operation was decided upon. In the third case it was decided that, in view of the length of time that had elapsed, traction was likely to fail; hence open operation was performed at once. Reduction proved extremely difficult. We now consider that, if traction had been employed for several days before the operation, the reduction would have been greatly facilitated.

OPERATIVE PROCEDURE

The patient was taken to the operating room with the skeletal traction maintained. Pentothal and later intratracheal ether anaesthesia were employed, and the patient was placed in the prone position. After the head and neck had been shaved and thoroughly prepared, a mid-line incision was made; the ligamentum nuchae was split; and the muscles were stripped off the spinous processes and the laminae as far as the intervertebral facets. The dislocated vertebrae were then inspected, and a blunt bone lever was placed beneath the inferior articular facet of each dislocated vertebra, and the facet was carefully levered over the tip of the corresponding superior facet of the vertebra below. During this manoeuvre, strong traction was maintained upon the skull calipers. After reduction the neck was hyperextended; the wound was closed; and the head, neck, and trunk were encased in plaster-of-Paris down to the iliac crests. The skull calipers were then removed.

POSTOPERATIVE TREATMENT

Discomfort lasted for two to three days after the operation, but then the patients were able to sit up in comfort. The sutures were removed at the end of three weeks, and a new plaster cast was applied. Standing was then permitted, and the patients were walking about the ward at the end of the fourth week. After the plaster had been removed, three months after the operation, the first man had a leather collar; and after an-

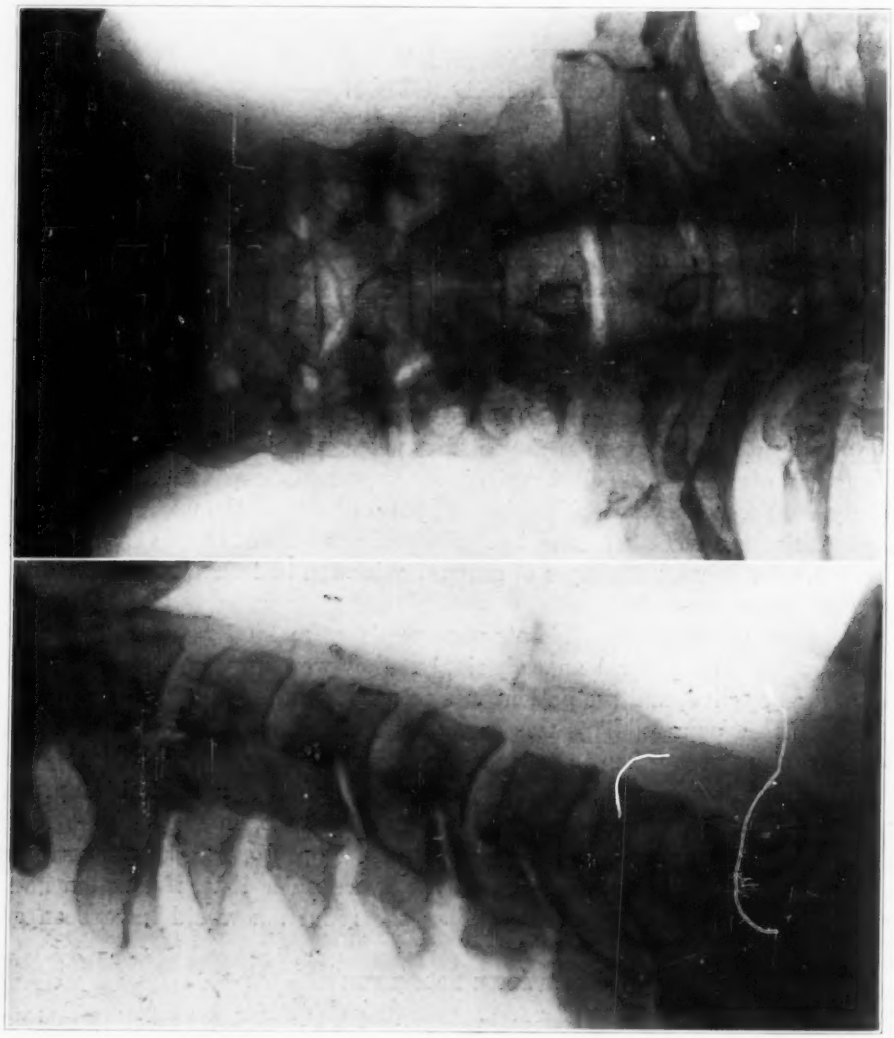

Fig. 1-B
After open reduction.

Fig. 1-A
Case 1. Before open reduction.

other month he was returned to duty. The other two patients, wearing plaster collars, were evacuated as ambulatory cases to the United Kingdom, within two months of the operation.

CASE REPORTS

CASE 1. The patient was injured in a jeep accident on March 7, 1944. Manual reduction was attempted under pentothal on the day of the injury, but was unsuccessful. Roentgenogram showed anterior dislocation of the sixth cervical vertebra on the seventh cervical vertebra. On March 12, 1944, a further attempt at manual reduction in this Centre was unsuccessful, and skull-traction calipers were then inserted with ten pounds of traction. The next day traction was increased to twenty pounds, and the head of the bed was raised eighteen inches. On March 15, roentgenograms showed that the dislocation was still present; and on March 18, traction was increased to thirty pounds. However, after two days, roentgenograms showed no improvement in position.

Open reduction was decided upon. The left lower articular process of the sixth cervical vertebra was found lying anterior to the left superior articular process of the seventh cervical vertebra. The vertebra was levered into the correct position, skeletal traction having been maintained throughout. A plaster-of-Paris cast was applied, and the skull calipers were removed. Postoperative roentgenograms showed that full reduction had been obtained. There was no additional injury to the cord.

The patient made a good recovery. He wore a support of plaster-of-Paris for three months, which was replaced by a leather collar.

CASE 2. On September 6, 1944, the patient was injured when he dived into shallow water. Attempted reduction under pentothal on the day of the accident was unsuccessful. Roentgenograms disclosed dislocation of the third cervical vertebra on the fourth cervical vertebra.

Manipulation was attempted on September 10, but was unsuccessful; and skull calipers were then applied with fifteen pounds of traction. Two days later roentgenograms showed that the dislocation was not fully reduced, so the traction was increased to twenty pounds, and the head of the bed was raised eighteen inches. On September 16, reduction was still incomplete, and traction was increased to

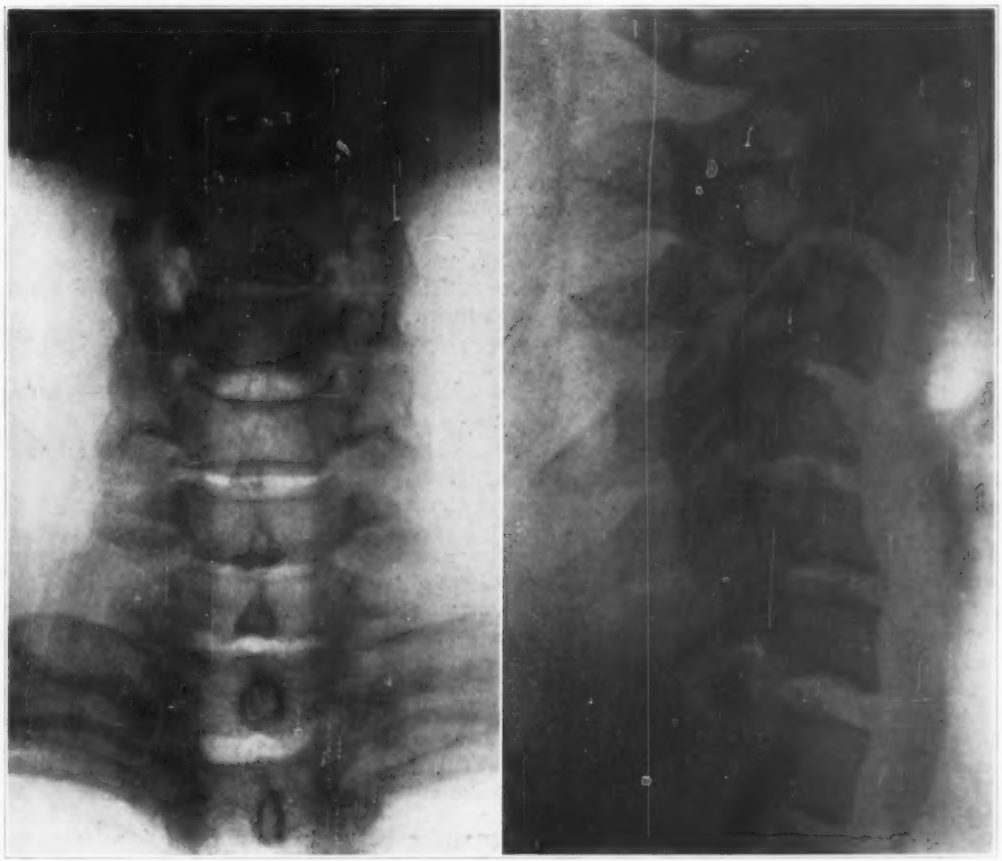

FIG. 2-A

Case 2. Anteroposterior view after injury.

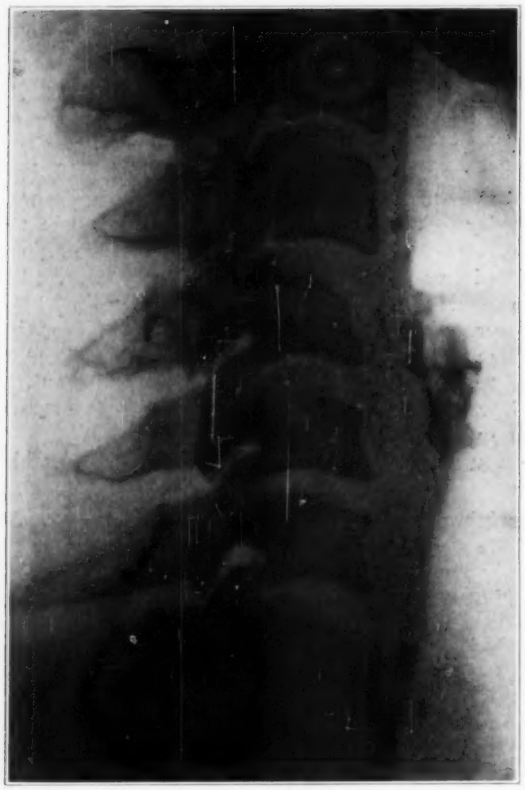

FIG. 2-B
Before operation, with twenty pounds of traction applied.

FIG. 2-C
After open reduction. Injury encased in plaster-of-Paris.

thirty pounds. Four days later roentgenograms showed the tips of the articular processes were still interlocking, and traction of thirty-five pounds was applied. On September 22, there was no improvement in the patient's condition, and operation was decided upon.

The lower articular process of the third cervical vertebra on the left side was lying in front of the upper articular process of the fourth cervical vertebra. The right side was not dislocated. The articular process was levered over into position. The tip of the articular facet of the third cervical vertebra had been fractured. A plaster-of-Paris cast was applied, and the skull calipers were removed. The postoperative roentgenograms showed complete reduction.

On November 10, 1944, the patient was wearing a plaster-of-Paris collar, and was evacuated as a walking case to the United Kingdom.

CASE 3. The patient was riding in an armored car when it blew up, and he was thrown from the car, landing on his head. This occurred on August 12, 1944, and the roentgenograms showed a fracture-dislocation of the fifth cervical vertebra on the sixth cervical vertebra.

On September 28, 1944, the patient was admitted to this Centre with the dislocation still unreduced. Operation was decided upon. Skull calipers were inserted for traction. Both of the lower articular facets of the fifth cervical vertebra were lying in front of the upper articular facets of the sixth cervical vertebra, and were firmly locked. The lamina of the fifth cervical vertebra was found to be fractured on the left side. The dislocation was reduced by means of bone levers, with difficulty. The fractured lower left articular facet of the fifth cervical vertebra was broken off during the manoeuvre. At the end of the operation the lamina of the fifth cervical vertebra was lying behind that of the sixth cervical vertebra, and the right posterior intervertebral joint was in normal position. Plaster-of-Paris was applied, and the skull calipers were removed. Postoperative roentgenograms showed complete reduction.

On October 30, 1944, the patient, wearing a plaster-of-Paris collar, was evacuated to the United Kingdom, as an ambulatory case.

UNILATERAL HYPOPLASIA OF LUMBOSACRAL ARTICULAR PROCESSES

A Case Report

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A rare, anomalous, unilateral hypoplasia, with resultant rudimentary lumbosacral articular processes and associated neural arch of the fifth lumbar vertebra, has been recently observed. The writer had never encountered a similar anomaly, and there seems to be no such case described in the literature.

A thirty-year-old white male, Private First Class in the Marine Corps, was admitted to the Hospital, September 18, 1944, complaining of low-back and right leg pain. He had first noticed the gradual onset of this pain five years previously, and there was no history of trauma. Lifting produced pain, as did prolonged walking and running, and occasionally the patient was awakened by the pain. By being careful, he was able to minimize the discomfort, and he felt well enough to enlist in the Marine Corps in January 1943. Following this, although he suffered occasional pain, he did not report to sick bay.

The patient stated that during the four months prior to admission to the Hospital, he had not been free of a constant dull ache. Acute exacerbations of pain in the low back occurred much more frequently, and were aggravated by sneezing, coughing, lifting, and stepping down on either foot. He described the pain as of a locking or catching nature in the low right back, with sharp shooting pain to the right hip and down the posterior thigh to the knee. He had also noted that the right leg tired more easily than the left.

The patient's history revealed that he had had scarlet fever, diphtheria, and pneumonia in childhood, also malaria in 1939. He had had an uncomplicated Neisserian infection in 1936.

Physical examination revealed a right leg limp. The right knee and hip were slightly flexed in the standing position, with the weight resting largely on the left leg. There was some pelvic tilt to the right, as well as body list to the right. Moderate spasm of the bilateral lumbar muscle was present, and there was tenderness to percussion over the lumbosacral and right sacro-iliac areas. Spinal motions were moderately limited in all directions. Forward bending was accompanied by rotation of the lumbar spine to the right. All motions, if forced, caused a "catching" pain in the lumbosacral and the right sacro-iliac areas.

Some atrophy of the right gluteal muscles was present. There was one inch of atrophy of the right thigh, and five-eighths of an inch of the right calf, compared to corresponding points of the left calf. Legs were equal in length. Straight-leg raising was bilaterally equal, and limited to 65 degrees. When leg-raising was forced, pain occurred in the areas of the right sacro-iliac and the posterior thigh. The reflexes and sensations of each leg were normal and equal. The physical examination was otherwise negative.

Routine laboratory tests revealed no unusual findings.

Roentgenographic studies of the lumbosacral spine, including the anteroposterior, lateral, and oblique views, showed rudimentary apposing articular processes on the left, between the fifth lumbar and first sacral segments. The left lamina of the neural arch of the fifth lumbar vertebra was also hypoplastic (Figs. 1, 2, and 3). The corresponding right articular processes and arch seemed normal. The spinous process of the fifth lumbar vertebra appeared normal, although some incomplete fusion of the neural arch of the first sacral segment was present. Narrowing of the fifth lumbar disc was not apparent. Moderate haziness of each sacro-iliac articulation indicated arthritic changes.

The patient was evacuated to the United States, October 27, 1944, as being unfit for field and combat duty.

DISCUSSION

Various developmental anomalies in the lumbosacral spine are well recognized, and not infrequently encountered. However, hypoplasia of the lumbosacral articular processes and associated laminae is rare.

FIG. 1

Unilateral left hypoplastic lumbosacral articular processes (arrow), also hypoplastic left lamina of fifth lumbar vertebra. Note haziness of each sacro-iliac articulation. This is a 15-degree angle projection from below upward. Compare with Fig. 4.

FIG. 2

Oblique view, showing normal right lumbosacral articular processes (arrow).

Fig. 4

Routine anteroposterior view which does not show well the left lumbosacral deformity because of overlapping shadows. Compare with Fig. 1.

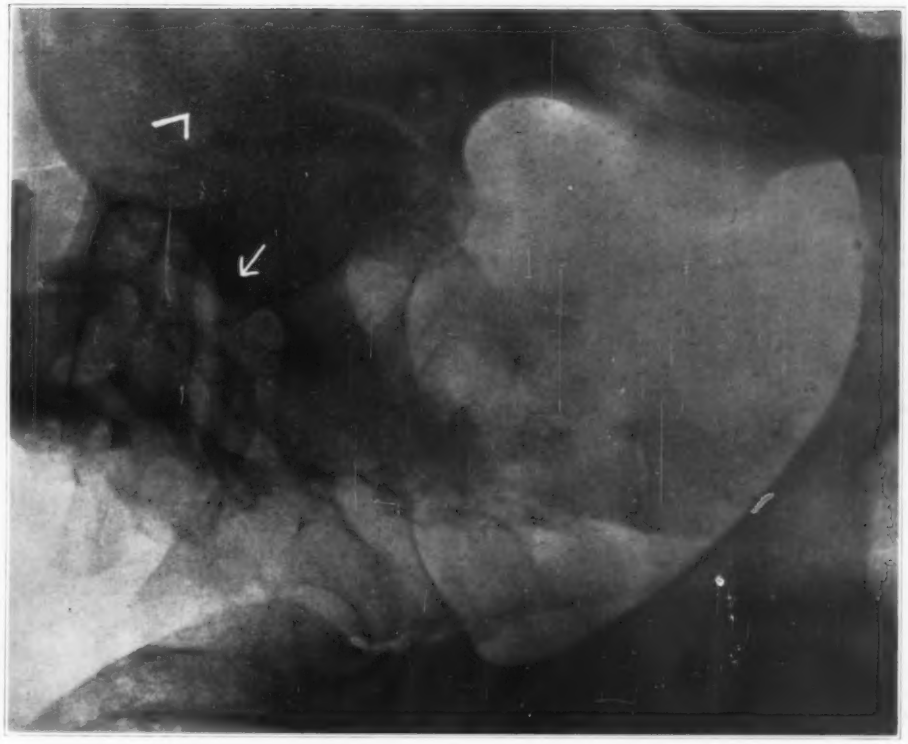

Fig. 3

Oblique view, showing hypoplastic left lumbosacral articular processes (arrow).

Ossification of each half of a neural arch, including the articular processes, is usually from one center. Variation occurs in the form of two primary centers of ossification instead of one for each half of the neural arch, especially for the fifth lumbar. The two centers, one for the anterior and one for the posterior portion of each half of the arch, are joined by a cartilaginous plate, and later bony fusion occurs in that portion of the arch between the superior and inferior articular processes.

In the present case, the anterior portion of the left half of the fifth lumbar arch—namely, the pedicle and the superior articular process—appeared normal; while the posterior portion, including the lamina and the inferior articular process, was underdeveloped. Thus, it is likely that there were two centers for the left half of the neural arch, the one for the posterior portion being hypoplastic.

Explanation of the rudimentary left articular process of the sacrum appears to lie either in the hypoplasia of the center of ossification for the left half of the sacral arch, or in the underdevelopment due to the lack of stimulus from an apposing normally developing inferior process of the fifth vertebra. The latter appears likely, as the two apposing processes are very small and rudimentary, and correspond in size, shape, and approximation.

A routine anteroposterior roentgenogram did not show the deformity well, which might have been overlooked because of overlapping shadows (Fig. 4). However, with a projection at a 15-degree angle from below upward in the anteroposterior plane, it was well seen (Fig. 1). Lateral views did not disclose the deformity, but the hypoplastic processes and laminae were well seen in the right and left oblique views.

The moderate arthritic changes of each sacro-iliac joint were assumed to be of traumatic origin. There was no evidence in the history or physical examination which could justify the assumption that the arthritis was due to an inflammatory or infectious condition.

One of the striking features of this case is that the patient suffered no pain on the side of the anomaly, but he had right low-back pain which was apparently due to the abnormal stress and strain placed upon the right low-back muscles, fasciae, and ligaments.

AN UNUSUAL TRAUMATIC CORTICAL LESION OF BONE

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The combination of giant cells and fibrous tissue forms the basic histological pattern for several distinct pathological lesions of bone. These lesions may involve the medulla or the cortex, and, in rare instances, may bear a direct relationship to trauma. They include such varied, yet possibly related, entities as benign giant-cell tumor, osteitis fibrosa cystica, ossifying hematoma, fibrous dysplasia of bone, and non-osteogenic fibroma. This entire group has been open to a wide variation of pathological interpretation, and "conceptions regarding their nature have ranged from that of simple repair or frank infection on the one hand, to true neoplasm and outspoken malignancy on the other." [4]

The following case presents a lesion, apparently traumatic in origin, in which the reaction of the bone to the injury has produced an unusual pattern of giant cells and fibrous tissue, a pattern which simulates, in many respects, a tumor of the benign giant-cell type.

CASE REPORT

CASE No. 114408. The patient, a sixteen-year-old white school boy, was first seen by one of the writers (J.J.C.) on April 7, 1944. At this time the boy complained of pain in the right leg, which had been present since March 28, 1944, when he had slipped on the steel tread of the stairs at school, and had twisted his ankle. Following this accident, he had been immediately taken to the Lynn Hospital, where roentgenograms were made of the right foot. As no fracture was noted, the foot was strapped, and

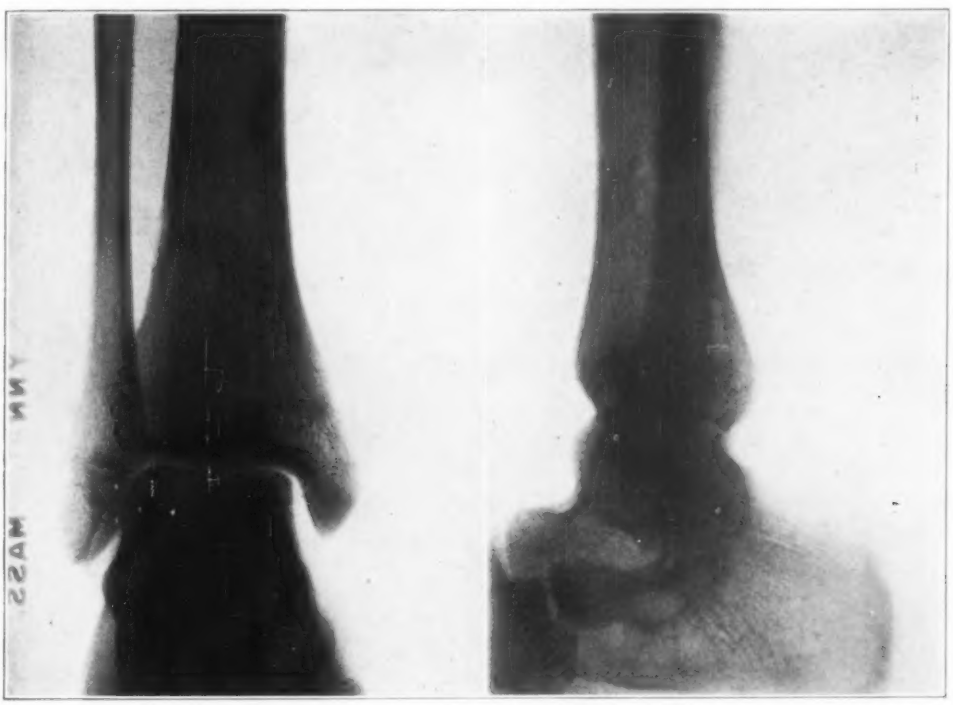

FIG. 1

Roentgenograms taken on the day the patient twisted his ankle, and approximately six months following the original hockey injury. The location of the lesion is well shown. It appears to be entirely limited to the cortex, which is being destroyed. There was sharply localized tenderness at this point.

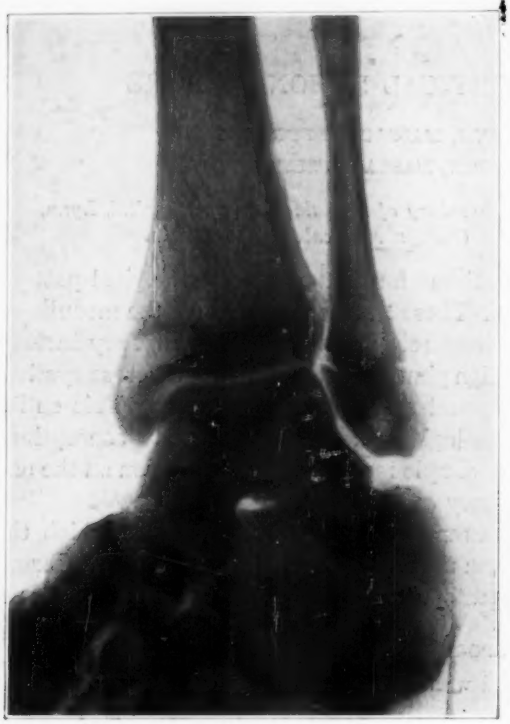

FIG. 2

A more detailed view of the original cortical lesion. The medulla is not involved, and the periosteum likewise shows no reaction.

the patient was told to report to the Clinic in two days. He did not return until April 7, ten days later, for removal of the strapping. At this time pain was still present, and on re-examination of the roentgenograms, a peculiar small defect was observed in the bone on the lateral aspect of the lower right tibia. Closer questioning revealed that this area had sustained previous injury approximately six months earlier, when, while playing hockey, the patient had been struck by the puck on the outer side of his right ankle. He had not been incapacitated by this injury, although he had limped for several days.

The patient was admitted at once to the Lynn Hospital for observation.

The examination showed oedema of the lower third of the right leg, with an acute and sharply localized area of tenderness over the lateral aspect of the lower right tibia, about three inches above the ankle. The temperature was normal, and physical examination was otherwise negative. Roentgenographic examination of the right lower extremity revealed a localized destructive lesion in the cortex of the lower lateral aspect of the tibia, about two or three inches (5 to 7.5 centimeters) above the ankle joint. The lesion involved the cortex only, and resembled somewhat a Brodie's abscess or a cortical cyst. There was no evidence of periosteal reaction at the site (Figs. 1 and 2). No definite roentgenographic diagnosis could be offered.

The patient was studied in the Hospital for a period of six days. Repeated blood and urine examinations were within normal limits. The blood serology was negative. The blood sedimentation rate was 6.0 millimeters per hour. Blood chemistry values on the day of admission (April 7) were:

Blood calcium *	13.2 milligrams per 100 cubic centimeters
Alkaline phosphatase	11.4 Bodansky units per 100 cubic centimeters
Serum inorganic phosphorus	6.6 milligrams per 100 cubic centimeters

Repeat tests five days later (April 12) showed:

Blood calcium	11.15 milligrams per 100 cubic centimeters
Alkaline phosphatase	13.9 Bodansky units per 100 cubic centimeters
Serum inorganic phosphorus	7.1 milligrams per 100 cubic centimeters

Roentgenograms of the skull, femur, and chest were negative.

At operation the periosteum appeared to be everywhere intact, and unthickened. A small area of bluish discoloration was seen in the periosteum. The bone beneath this spot of discoloration felt soft, as though there were a defect in the continuity of the cortex. The periosteum was then split, and the area of the lesion in the underlying cortex was exposed. The involved area appeared to be gelatinous, and measured about 1.5 centimeters in diameter. This area of soft gelatinous tissue was situated within the cortex, and had replaced the bone. The overlying periosteum and the entire section of involved tibia were removed.

Postoperative convalescence was uneventful. Roentgenograms taken after the operation showed a complete excision of the bone lesion (Fig. 3).

Since his discharge from the Hospital, the patient has been seen regularly in the Orthopaedic Clinic. He has been entirely free of symptoms. Blood studies made on the day of his discharge from the Hospital showed:

Serum inorganic phosphorus	4.8 milligrams per 100 cubic centimeters
Alkaline phosphatase	2.8 Bodansky units per 100 cubic centimeters
Acid phosphatase	3.0 King-Armstrong units per 100 cubic centimeters

* This lone value for blood serum calcium was not confirmed; all other values listed, however, were confirmed by duplicate and triplicate determinations.

FIG. 3

Roentgenograms taken immediately after the operation to show the excision of the original lesion in its entirety, leaving a defect at the site of the tumor. The adjacent bone appears normal, and the margins of the operative defect are clear-cut and sharp.

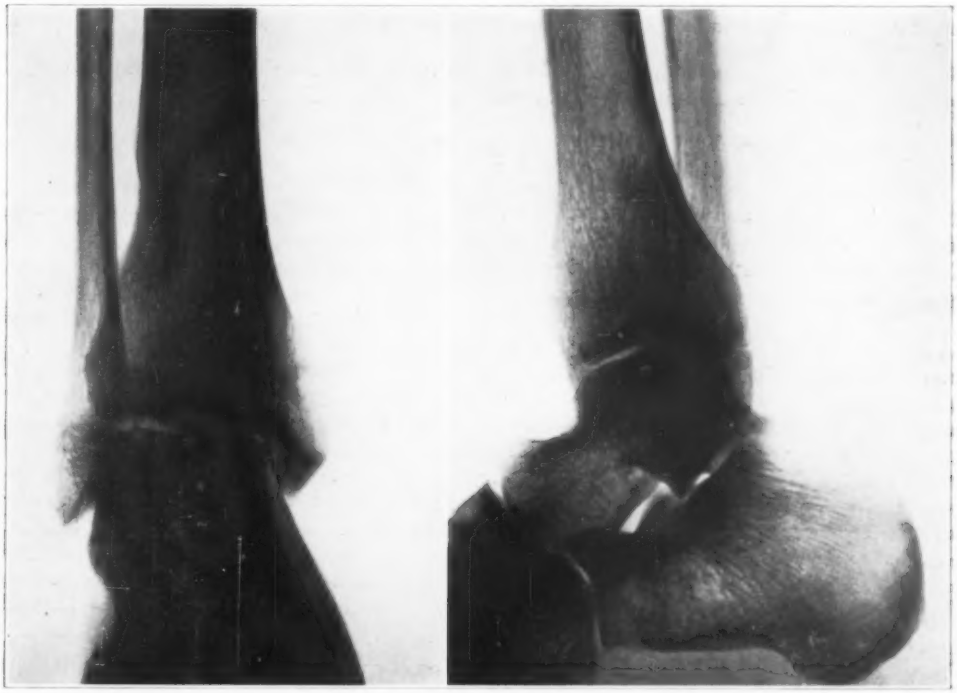

FIG. 4

Roentgenograms taken four months after the operation, showing a filling-in of the postoperative defect with the return of the bone to normal.

FIG. 5

Photomicrograph (× 100) showing the nature of the cortical lesion and its encroachment upon and dissolution of the bone. The pattern of the fibrous stroma and the relationship of stroma and giant cells stand out clearly (stained with eosin methylene blue).

Roentgenographic examination of the site of the tumor four months after operation (August 9) showed a return of the bone to normal, with a healing of the operative defect (Fig. 4).

PATHOLOGY

The gross specimen consisted of a single wedge-shaped piece of cortical bone measuring 1.5 by 1.0 by 0.8 centimeters. The central portion of the specimen showed an irregular defect in the outer surface of the cortex. This defect was due to the replacement of the bone by soft, pinkish-gray, friable tissue, which lay within the substance of the cortex. The entire area occupied by this tissue measured less than 1.0 by 0.6 by 0.6 centimeters. The specimen was fixed in Zenker's solution for histological study.

Sections (Figs. 5, 6, 7, and 8) show a tumor-like growth, composed chiefly of fibrous tissue and giant cells, replacing cortical bone. The growth extends from beneath the periosteum through the greater part of the thickness of the cortex, but it does not encroach upon the medullary cavity. This fibrous tissue is composed chiefly of irregular bundles of spindle cells, resembling fibroblasts. These cells and their nuclei vary in size. The nuclei are oval, clear, and vesicular, and show small but prominent fragments of nucleolar chromatin. Some intercellular collagen is seen, but this is sparse. Mitotic figures are scarce. Scattered among the spindle-shaped stroma cells are numerous multinucleated giant cells of the foreign-body type. The giant cells vary in size, shape, and in the number of nuclei. As many as ten nuclei are seen in the larger cells. The distribution of these giant cells is not uniform, and in places they tend to form small clusters. Fresh hemorrhage is scattered throughout this lesion, and in addition a moderate amount of golden-yellow hemosiderin is found, lying free in the tissue as well as within the stroma cells and other phagocytes. Although there is no definite association of the giant cells with the hemorrhage, they tend to clump most prominently in the regions of greatest bleeding. Foam cells are absent.

There is no evidence of formation of new bone, nor is there any evidence of acute inflammation, or of necrosis of bone.

On the basis of the gross and histological features of this lesion, it is felt that the tumor-like growth in bone represents a response to trauma, which occurred approximately six months before examination. This unusual reparative response of subperiosteal bone to injury resembles in its growth a benign giant-cell tumor. There is no evidence of malignancy.

DISCUSSION

Possibly the most striking feature of this case is the limitation of the destructive lesion to the cortex of the bone. This is a very unusual location for a benign tumor-like growth. Cortical lesions arising in the cortex are almost invariably inflammatory in nature or frankly malignant. The less virulent inflammations of bone, including chronic localized pyogenic osteomyelitis, syphilis, and tuberculosis, however, do not as a rule conform to the features of the lesion in this case; nor is the picture consistent with osteogenic sarcoma.

Destruction of the bony cortex has been described several times in association with generalized von Recklinghausen's neurofibromatosis[1,5,8,9], or even in association with a localized nerve-sheath tumor, a neurilemmoma[3]. Such disease processes, when seen in the cortex, usually start with an involvement of the periosteal nerves, and lead to a gradual excavation of the bone by the invading tumor. These nerve tumors, however, show their own characteristic histological patterns which are quite different from that of the giant-cell lesion herein described.

Individual osseous lesions of neurofibromatosis may bear a striking roentgenographic similarity to the traumatic lesion here described, even though the lesions vary so considerably histologically. This is well illustrated in a case recently reported by Green and Rudo, wherein a rounded defect was found in the tibia, which was involved by neurofibromatosis. The authors rightfully interpreted this defect as the first step in the development of a neurofibroma within the bone. The roentgenogram of this neurofibromatous lesion, as it appeared in the publication of Green and Rudo, bears a striking similarity to the lesion under discussion, and serves to emphasize that the two processes cannot be completely

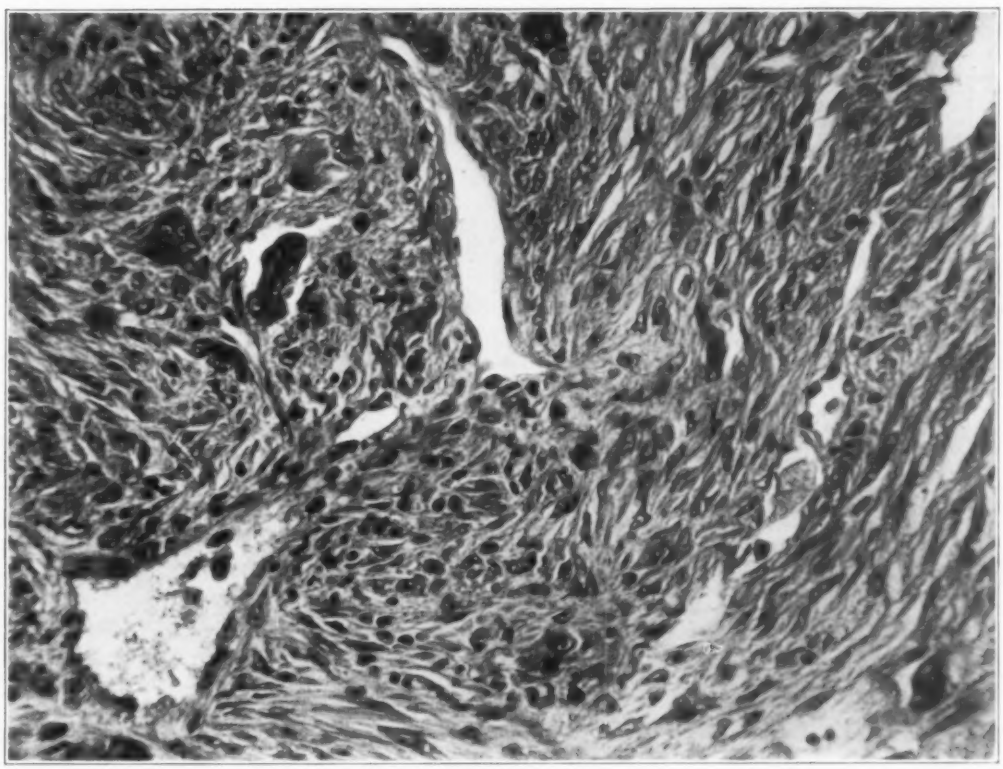

FIG. 6

Photomicrograph (× 380). The lesion was moderately vascular, being supplied by irregular blood channels formed by the peculiar stromal fibrous tissue. In almost every field there could be seen, under the microscope, fresh hemorrhage and old blood pigment. There was no evidence of new-bone formation.

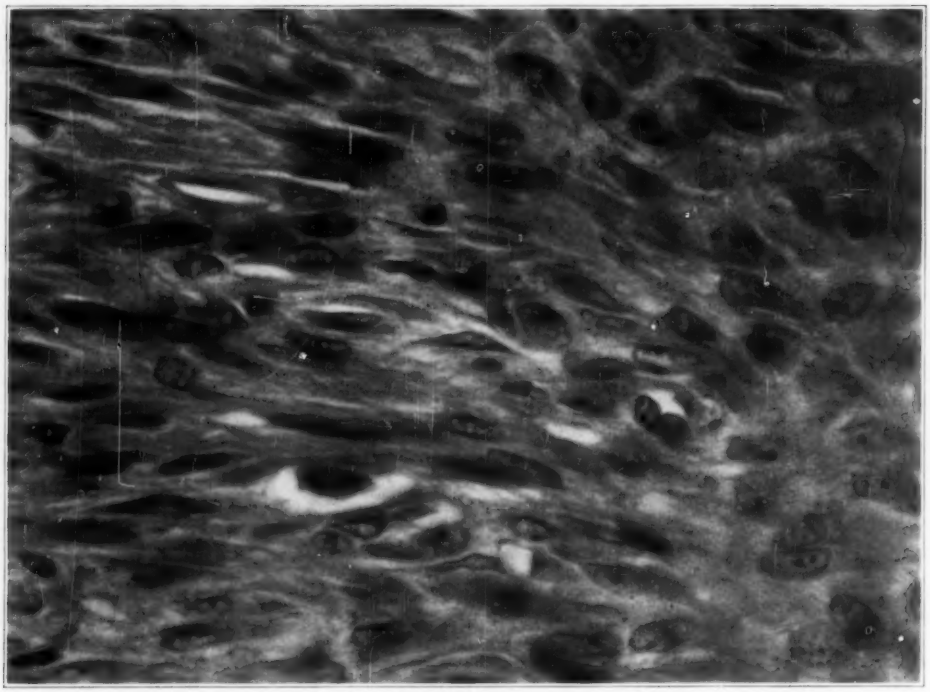

FIG. 7

Photomicrograph (× 640). The stromal-cell nuclei are oval to round, vesicular, and contain prominent nucleolar fragments. Their cell outlines are not always distinct, and the amount of intercellular collagen is variable, but never abundant.

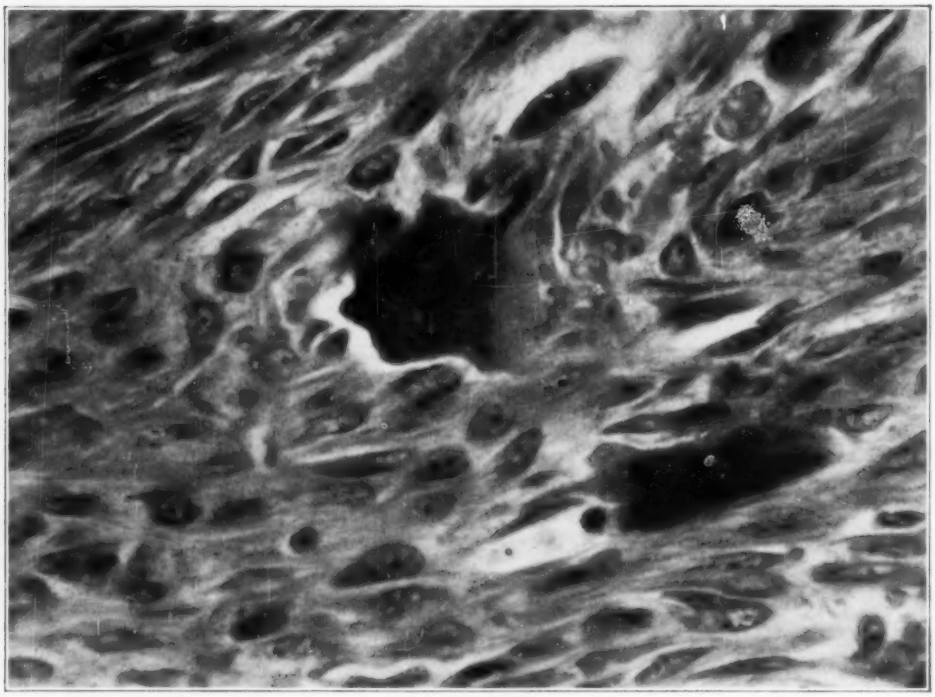

FIG. 8

Photomicrograph (× 640). The association of giant cells and stroma is intimate. The nuclei of the giant cells resemble closely those of the stromal cells. Rare mitoses are seen in the stroma.

differentiated by the roentgenograms alone. Such are the common lesions of bone associated primarily with subperiosteal cortical destruction.

As an expanding medullary lesion, the giant-cell tumor of bone is readily identified, and would probably occasion no confusion roentgenographically with a lesion such as we have described here. However, more recently it has been shown that an essentially similar lesion can arise within the cortex beneath the periosteum. Geschickter and Copeland have accumulated four such cases. They included also the lesion described by Cone under the heading of "ossifying hematoma". These subperiosteal benign giant-cell lesions in all instances followed trauma to the bone with hemorrhage and separation of the periosteum.

Certainly the close association of Geschickter's subperiosteal giant-cell tumors with trauma, the location of the lesion within the cortex, and the dissolution of the cortical bone are suggestive of the case herein described. The association of giant cells with fibrous tissue is also consistent. However, the similarity between these two lesions cannot be followed completely. In the case described herein, removal of the periosteum revealed no "shell of bone", and upon incision there was no "cavity containing blood". True, there was evidence of old and fresh hemorrhage in the lesion, and certainly this hemorrhage is significant, but probably does not warrant the conclusion that hemorrhage and disturbance of the periosteal blood supply is the primary cause of the lesion, as Geschickter believes to be the case with giant-cell tumors.

Although Geschickter and Copeland made no mention of new-bone formation in their four cases of subperiosteal giant-cell tumor, they included Cone's case of ossifying hematoma as a typical example of the lesions they were discussing. An outstanding feature of Cone's "ossifying hematoma" was the formation of new bone within the zones of organizing hemorrhage. In the case under discussion, new-bone formation is conspicuous by its absence.

The absence of new-bone formation is the second outstanding feature of this cortical bone lesion. Jaffe and Lichtenstein have described a benign tumor of bone characterized by the lack of bone formation under the heading of "non-osteogenic fibroma of bone". Clinically most of the patients with non-osteogenic fibromata, while giving no history of trauma, had pain or swelling of long duration about a joint. The usual site for this lesion was the shaft of a long tubular bone, usually of the lower extremity. Again the lesion was not a cortical one, but rather began in the medulla. The authors remarked that, "the lesion may show up roentgenographically as a sharply delimited, eccentric, somewhat loculated area of rarefaction traversing the bone and even bulging it out on both sides". Pathologically the lesion of non-osteogenic fibroma was described as "consisting grossly of several discrete but contiguous yellow-brown fibrous foci whose basic microscopic pattern was found to be made up of whorled bundles of spindle-shaped connective-tissue cells, loosely interspersed with small multinuclear giant cells, though, in some lesions, areas containing foam cells may also be present and even prominent".

Upon comparing the lesion under discussion with the non-osteogenic fibroma of Jaffe and Lichtenstein, one is struck by the similarity of the histological patterns, and the dissimilarity in the locations of the lesions.

The possibility that this lesion might be a variant of osteitis fibrosa or of fibrous dysplasia[8] is also remote, for both of these processes are primarily medullary lesions, and are capable of producing bone.

SUMMARY

An unusual destructive lesion of bone was first examined six months following trauma to the tibia; it was limited to the cortex of the bone, and showed no periosteal or medullary involvement. Histologically the cortical bone was replaced by fibrous tissue and giant cells. There was associated old and fresh hemorrhage, but there was no evidence of new-bone formation.

This lesion does not fall within any definitely known category of bone pathology. It

is best considered as a benign lesion which represents an unusual reparative response on the part of the bone to injury.

NOTE: The authors wish to extend their deepest gratitude to H. E. MacMahon, M.D., Henry Jaffe, M.D., Joseph L'Episcopo, M.D., and Jean Oliver, M.D., for their help with the histological interpretation of this lesion, and to Herman Osgood, M.D., for his assistance with the roentgenographic studies.

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SAGITTAL CLEFT (BUTTERFLY) VERTEBRA

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One hundred years ago von Rokitansky described a congenital division of the twelfth thoracic vertebral body into two lateral halves with an intervening sagittal cleft. Since then, the literature dealing with this condition has not been abundant, particularly in English. The majority of reported cases have been in the form of single case reports from European clinics. In some of these cases, the anomaly has been reported as a cause of symptoms in the back, although in others there have been no symptoms. In a given case, the clinical evaluation of this anomaly may present certain difficulties. The following cases illustrate several of the typical features of the condition.

CASE REPORTS

CASE 1. A private, aged thirty-eight, was admitted to Bruns General Hospital on December 31, 1943. Six days before he had been struck by an automobile, and a plaster-of-Paris body jacket had been applied at another hospital. The patient stated that for five years he had suffered low-back pain, which was located in the mid-lumbar region. The pain had never been severe, and the patient had never consulted a doctor. He had been able to perform his civilian duties as a car painter without difficulty. However, with the increased activity of Army life, he had noticed increased pain in the affected area. Roentgenograms revealed an unusual vertebral anomaly: the body of the third lumbar vertebra was divided into two somewhat unequal halves (Fig. 1-A); the left half was slightly larger than the right, producing a mild left lumbar scoliosis. An indentation was present on the right side of the third lumbar vertebral body, but absent on the left. Very slight narrowing of the adjacent intervertebral spaces was noted. The lateral view (Fig. 1-B) showed anterior wedging of the halves of the third lumbar vertebra with possible slight compensatory enlargement of the anterior portion of the fourth lumbar vertebra. A small hypertrophic spur was seen at the anteroposterior margin of the fifth lumbar vertebral body. The right and left oblique views (Figs. 1-C and 1-D) showed a slight relative narrowing of the joint spaces between the adjacent articular facets of the second and third lumbar vertebrae. The neural arches were intact, and showed no evidence of defect.

Clinically, examination of the spine was not remarkable, except for some loss of the normal lumbar curve, tenderness to percussion over the mid-lumbar spine, and a slight left lumbar scoliosis on extreme flexion of the spine.

The patient soon lost his lumbar pain, and was released from the hospital after full recovery from a simple fracture of the left fibula, suffered at the time of the accident. He was assigned to duties which did not involve heavy lifting, prolonged walking, standing, and drilling.

CASE 2. A corporal, aged twenty-three, was seen in the Orthopaedic Clinic at Bruns General Hospital on July 19, 1944. His chief complaint was thoracic and lumbar backache, which occurred upon heavy lifting, as well as during prolonged hiking with a pack. This pain first occurred when the patient was sixteen, and at that time it was noticed that his back was rounded. In civilian life, the patient had given up a position as a waiter because of the back pain, which occurred while he was carrying heavy trays of silverware. Since entering the Army, the patient's duties had necessarily been limited because of this disability.

Clinical examination showed a marked kyphosis at the level of the tip of the seventh thoracic spinous process. The kyphosis was fixed, resulting in some limitation of motion in the thoracic spine. A compensatory increase of the normal lumbar curve was present.

Lateral roentgenogram (Fig. 2-A) revealed an absence of the anterior third of the eighth thoracic vertebra, with marked wedging of the remaining portion of the vertebral body. The anterosuperior margin of this vertebra produced an indentation in the inferior surface of the seventh thoracic vertebra. Slight irregularities in the end surfaces of the adjacent vertebrae were noted. The anteroposterior view (Fig. 2-B) showed, in addition to the previously described eighth thoracic vertebra, a division of the seventh thoracic vertebra into two halves by means of an irregular narrow cleft. There was no anterior wedging or lateral displacement of the two halves of the seventh thoracic vertebral body.

It was recommended that the patient be assigned to light duties which would not place an undue strain on his back.

FIG. 1-A

Case 1. Roentgenogram showing the body of the third lumbar vertebra divided into two unequal halves.

FIG. 1-B

Lateral view. The wedging anteriorly of the third lumbar vertebra simulates a compression fracture.

FIG. 1-C

Right oblique view.

FIG. 1-D

Left oblique view.

FIG. 2-A

Case 2. Lateral roentgenogram showing absence of the anterior third of the eighth thoracic vertebra with wedging of the remaining portion of the vertebral body.

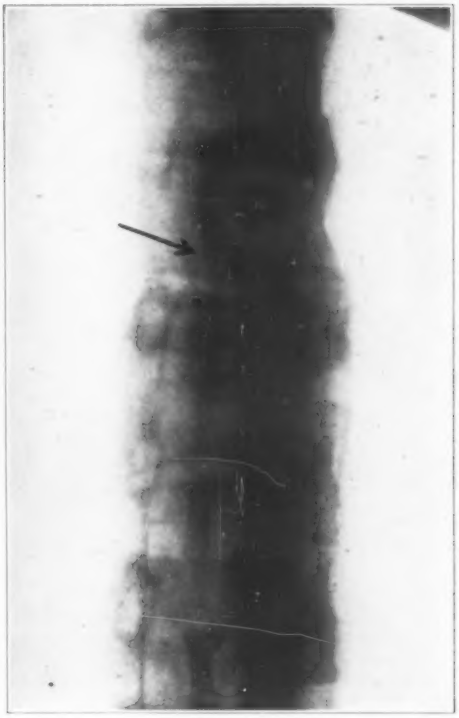

FIG. 2-B

Anteroposterior view. A narrow irregular cleft separates the seventh thoracic vertebra into two halves.

In this case, the cleft seventh thoracic vertebra was not compressed anteriorly, nor were the lateral masses displaced, so there is no evidence to suggest that the cleft vertebra caused the symptoms. In contrast, the grossly malformed eighth thoracic vertebra produced a severe kyphosis and a secondary lumbar lordosis. Sagittal cleft vertebra may be associated with other malformations of the vertebrae and the ribs.

ROENTGENOGRAPHIC FINDINGS

The typical "butterfly" appearance is seen on the anteroposterior view, where the wings of the butterfly are represented by the two symmetrical halves of the vertebral body. The two halves may be separated by a wide cleft, bridged by strands of bone, a bony bridge, or demarcated only by a narrow sagittal cleft between the two halves (Fig. 3 *A*, *B*, *C*, *D*). In this typical picture, the halves are of equal size; however, they may be slightly unequal, displaced laterally or wedged anteriorly. Resultant scoliosis or kyphosis may be noted. The adjacent intervertebral spaces may be narrowed, but not collapsed. Compensatory changes may occur in the adjacent vertebrae, as if an attempt had been made to fill in the deficiencies in the form of the anomalous vertebra. Other vertebral and rib anomalies may be associated.

TREATMENT

Treatment is not indicated in asymptomatic cases, and in cases with only mild deformity. In the usual case, correction of the kyphosis or scoliosis is not practical. Limitation of activity and the avoidance of heavy lifting will result in relief of pain in certain cases. Pain is also relieved by the use of an external support; internal fixation by means of a bone-graft has apparently seldom been warranted up to the present decade.

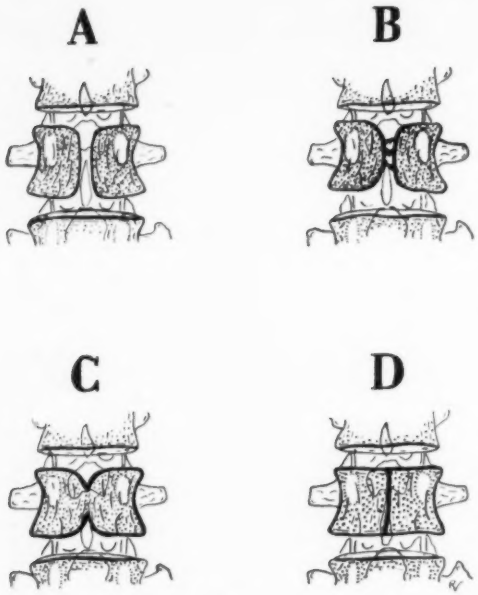

FIG. 3

Variations in the sagittal cleft which may be *A*: wide, *B*: bridged by small bony strands, *C*: crossed by a bony bridge, or *D*: narrow. Further variations in the butterfly appearance result from inequality of the vertebral halves or their lateral displacement.

CONCLUSIONS

The reported cases of sagittal cleft vertebra are too few to permit a final clinical evaluation of the condition. It is evident, however, that from an orthopaedic standpoint, the cases fall into two principal groups, the symptomatic and the asymptomatic. The symptomatic group are usually characterized clinically by the presence of mild, moderate, or severe local deformity occasionally followed by pain, and roentgenographically by anterior compression of the vertebral body halves, and less frequently, by inequality of the two vertebral halves or their lateral displacement. In these cases, the sagittal cleft roentgenographically distinguishes the anomaly from unreduced vertebral body fractures with anterior or lateral compression and lateral displacement. Clinically the symptomatology may resemble that seen in old unreduced fractures of the vertebral body. Certain asymptomatic cases are characterized clinically by the absence of deformity. Roentgenographically they show division, not always complete, of the vertebral body into two equal halves, without anterior compression or lateral displacement. It seems unnecessary to discuss in detail the embryological and pathological aspects of this anomaly, which have been thoroughly reviewed so recently by Ehrenhaft.

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GUNSHOT WOUND WITH OSTEOMYELITIC DESTRUCTION OF THE BODY OF THE THIRD CERVICAL VERTEBRA

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A private was admitted to Deshon General Hospital on October 26, 1944, as an overseas casualty, having been wounded by a machine-gun bullet in France on August 28, 1944. The bullet entered the right side of his jaw, passed down through the body of the third cervical vertebra, and lodged in the soft tissue on the left side of his neck. As a result of this wound, he suffered a compound fracture of the ramus of the mandible on the right, and a compound fracture of the third cervical vertebra. He had received prompt medical attention at the scene of injury, and was quickly transported to an Evacuation Hospital in the Zone of Combat, where the wound over his jaw was closed, his teeth were wired, and the foreign body was removed from the left side of his neck. From the Evacuation Hospital, he was taken to a General Hospital in England, where he arrived on August 31, 1944. It was not immediately apparent that he had suffered the fracture of the third cervical vertebra, but, at the General Hospital in England, the fracture was reported, and the patient was placed in a Minerva-type plaster cast in order to immobilize his neck (Fig. 1). The fractured jaw was treated by wiring with elastic-band traction for immobilization. His course in the General Hospital was complicated by the development of pneumonia, which readily responded to sulfadiazine therapy. On October 7, 1944, he was boarded for the Zone of the Interior, and transported back to the continental limits of the United States, finally arriving at Deshon General Hospital.

Upon admission, he was in fair physical condition, considering the gravity of his injuries. His cast was in good condition, and his jaws were adequately immobilized with a good reduction of the mandibular fracture. Although temperature was within normal range, the patient had a hacking cough, productive of a considerable quantity of thick sputum. His complaints were limited to the cough, with some pain in the chest, and to radiation of pain down the left arm whenever he coughed. An offensive odor to his cast was found to result from a pressure sore, which had developed over the posterior aspect. It was necessary to remove the plaster cast in order to treat the pressure sore, to get adequate views of the cervical fracture, and to examine his chest satisfactorily. Roentgenograms of the cervical spine showed a destructive process present in the body of the third cervical vertebra (Fig. 2). Roentgenograms of the lung fields showed either a pneumonitis or an atelectasis. The temperature and white-blood-cell count remained within normal limits, although the sedimentation rate had increased, and a culture of the sputum showed pneumococci. In order to immobilize the cervical spine adequately, Crutchfield tongs were introduced through the outer table of the skull on November 13, 1944, and ten pounds of traction were applied to the head.

Adequate examination of the nose and throat was impossible at this time, because of stiffness of the temporomandibular joints, brought on by the prolonged wiring which the mandibular fracture had necessitated. However, by November 1, the mandibular fracture was sufficiently healed to allow adequate mobilization of the joint to be started. The patient was placed on a rigid regime of gum chewing, in an effort to mobilize the joint sufficiently to permit a satisfactory laryngoscopic examination. During the first week of November the patient began to show evidence of sepsis, as seen in the increased white-blood-cell count and a rising fever, which at one time rose to 104 degrees and was accompanied by a chill. Along with these signs of acute infection, the patient began to complain of increasing numbness and weakness in the upper extremities. By the middle of November, the neurological findings had progressed to the point where the patient showed marked motor weakness of both arms, hyperaesthesia of the arms and thorax, and questionable pyramidal-tract signs in the legs. It was at this time that a sufficiently satisfactory laryngoscopic examination was possible, and a marked swelling of the posterior pharynx was seen; the tissues showed a moderate diffuse reddening. Repeated cervical roentgenograms also showed a retropharyngeal swelling consistent with the laryngoscopic findings, in addition to further destruction and fragmentation of the body of the third cervical vertebra. A lumbar puncture showed a complete spinal-fluid block with protein of 149 milligrams per 100 cubic centimeters, and fourteen cells per cubic millimeter. At the onset of his febrile reaction, the patient had been placed on intramuscular injections of penicillin every three hours for a daily total of 200,000 units. His atelectasis had cleared up in the previous weeks, as evidenced by negative clinical findings, and the absence of roentgenographic pathological signs. A diagnosis of paralysis of the spinal cord at the level of the third cervical vertebra as a result of an epidural abscess was made, and surgical interference appeared urgent. Opinion was divided as to the proper surgical procedure. A decompression of the cord by means of a laminectomy, an inci-

FIG. 1

Lateral roentgenogram of cervical spine taken overseas. This shows fracture of the third cervical vertebra.

FIG. 2

Lateral roentgenogram of cervical spine taken November 7, 1944, showing advanced osteomyelitic destruction of the third cervical vertebra. Note soft-tissue swelling anteriorly.

FIG. 3

Lateral view of cervical spine taken in December, following extrusion of large fragment, showing virtual disappearance of the body of the third cervical vertebra.

sion through the posterior cervical triangle for drainage of the lateral retropharyngeal space, and an incision directly into the dome of the abscess were considered. Fortunately, the abscess ruptured spontaneously into the pharynx before a decision was made. The first evidence of the spontaneous decompression was seen, when the patient coughed up several small pieces of bone. Laryngoscopic examination showed a draining fistulous opening in the posterior pharynx, just to the right of the mid-line on a level with the superior edge of the epiglottis. Suction was applied to the sinus without any great improvement in the amount of drainage obtained. The sinus continued to drain sufficiently to decompress gradually the retropharyngeal abscess, as evidenced by gradual recession in the pathological and neurological findings. On December 13, 1944, a laryngoscopic examination showed the fistulous tract to be still patent, and a grayish substance resembling a piece of bone was seen lying in the tract. It was impossible to grasp this fragment of bone with forceps, and suction was again applied to the tract in an effort to increase the amount of drainage. Apparently, as a result of the suction and the attempted extraction, the patient developed a severe coughing attack that evening, and spontaneously coughed up a fragment of bone, approximately one inch square, which resembled in structure the cortex and cancellous framework of a cervical vertebra. A considerable amount of foul-smelling pus accompanied the expectoration of this fragment of bone (Fig. 3).

From this time on, the patient showed steady improvement. The temperature returned to normal limits, the white-blood-cell count fell to a normal level, and the sedimentation rate started to drop. The neurological findings showed steady improvement: motor power increasing, hyperaesthesia receding, while the evidence of pyramidal-tract involvement disappeared. Roentgenograms of the cervical spine showed a virtually complete disappearance of the third cervical vertebra, with a regression in the previously reported retropharyngeal swelling. Lumbar punctures performed shortly thereafter revealed normal spinal-fluid dynamics with no evidence of block, normal chemistry, and a normal cell count. The fistulous tract remained patent for approximately three more weeks, although gradually diminishing in size. The amount of drainage from the tract became greatly decreased, until the sinus healed spontaneously about the middle of January 1945. With the gradual subsidence of the patient's acute infection, his general condition improved markedly. His spirits rose, and he was able to eat sufficiently to regain his strength and weight. His progress was so rapid that on February 21 his physical condition was sufficiently good to permit the formidable surgical procedure of a fusion of the second, third, and fourth cervical vertebrae.

At this time the patient showed no evidence of any neurological involvement, having regained full sensation in the upper extremities with a return to normal of his muscular strength. Prior to the operation, a plaster cast of the Minerva type was reapplied with the neck held in extension. In order to assure sufficient immobilization and traction to the neck, a walking iron was incorporated in the headpiece of the jacket, so that the Crutchfield tongs which had been applied previously could be fastened to the

FIG. 4

Side view of cast with incorporation of tongs traction to skull.

FIG. 5

Posterior view of cast with incorporation of tongs traction to skull.

FIG. 6

Lateral view of cervical spine, taken four weeks after operation at time of plaster change and removal of Crutchfield tongs.

crosspiece of the walking iron, and thus maintain adequate traction on the neck during the cervical fusion. Adequate exposure of the operative field was obtained by removing the posterior portion of the plaster cast covering the head and neck. The walking iron with the suspension through the tongs served to immobilize the head adequately, even after this portion of the cast had been removed (Figs. 4 and 5).

The fusion of the cervical spine proved even more difficult than had been anticipated, because of the tremendous amount of bleeding encountered in an effort to expose the cervical spine. It was felt that this bleeding undoubtedly arose from the congestion due to the previous infection of the vertebral body. The bleeding was controlled with difficulty, and the only adequate exposure of this field was obtained when the patient went into a mild primary shock with a drop in blood pressure. Even though the blood pressure remained low, it was possible to expose completely the posterior elements of the first, second, third, fourth, and fifth cervical vertebrae, and an operation of the Albee type was performed, by raising the cortical portions of the lamina and spines of the second, third, and fourth cervical vertebrae, and inserting a three-inch tibial graft on either side of the spinous processes for fixation. In addition to the grafts, bone chips were packed between and on top of the lamina of the second, third, and fourth cervical vertebrae. It was felt that an attempt to remove the articular cartilage of the involved vertebrae in the usual fusion of the Hibbs type would be risky, because of the tremendous amount of bleeding and the shocked condition of the patient. It was possible to complete the operation only after heroic amounts of plasma had been administered. The patient received three pints of plasma and three pints of blood during the operation which lasted two and a half hours.

The patient's postoperative course was as uneventful as his operative course was stormy. His highest postoperative temperature was 100 degrees, and, other than receiving two more transfusions for his secondary anaemia, no measures were needed beyond the usual postoperative regimen. He received penicillin intramuscularly and sulfadiazine by mouth, as prophylactics against reinfection. He was able to sit up in bed at the end of the tenth postoperative day, and was up in a wheel chair by the end of the second week. The sutures were removed at the end of four weeks, the wounds having healed *per primam*, and a new Minerva cast was applied. The Crutchfield tongs were then removed, because sufficient support was obtained by means of the plaster immobilization alone (Fig. 6).

It is, of course, too early to evaluate the ultimate result in this case. It is hoped that a good strut of bone posteriorly, running from the second to the fourth cervical vertebra, will compensate adequately for the loss of the third vertebral body. When the bone grafts have become strong enough, it is felt that all danger of a sudden flexion of the neck causing severance of the cord will be obviated. Since the first cervical vertebra was not involved in the operative procedure, the patient should obtain a fairly normal range of motion in his head and neck. It will be impossible to evaluate properly this case for at least six months or a year after the operation, and some form of external fixation will be needed during that time.

INTRA-ARTICULAR OSTEOCHONDRAL FRACTURES AS A CAUSE FOR INTERNAL DERANGEMENT OF THE KNEE IN ADOLESCENTS

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The two most common causes of internal derangements of the knee in young adults are injuries to the menisci and osteochondritis dissecans. However, injury to the meniscus is not the most common cause of knee-joint disabilities in children. The writer has seen two cases of a comparatively rare condition, that deserves more publicity, since there are undoubtedly many similar cases that go unrecognized or undiscovered until arthrotomy has been performed under the mistaken diagnosis of meniscus injury. Our cases and those already reported in the literature indicate that these intra-articular osteochondral fractures usually occur in juveniles and adolescents. It is essential that the correct diagnosis should be made at the earliest moment, so that the surgeon may perform the arthrotomy without delay, in order to prevent further damage to the cartilage and other structures within the knee joint.

Several recent reports indicate that it has been possible to make a positive diagnosis in these cases prior to operation. Milgram, in reviewing the literature on a condition which he refers to as "tangential osteochondral fracture of the patella", lists a number of reports of intra-articular osteochondral fracture of the patella. Of the cases which Milgram himself described fully, and five other cases referred to by him, most occurred in children and adolescents.

There seems to be no essential difference in the mechanism of production of the injury to the patella with subsequent formation of an osteochondral intra-articular body from that structure, and the two cases herein reported in which the osteochondral intra-articular body arose from the femoral condyles.

CASE REPORTS

CASE 1. D. H., male, aged fifteen, injured his knee while skiing, lacerating it when he fell on a stone. Physical examination showed a diagonal laceration of one and one-half inches (3.75 centimeters) over the lateral portion of the left knee joint, extending into the joint. Roentgenogram (Fig. 1) showed a small fragment of bone, lying on the lateral aspect of the lateral condyle of the femur. It was the opinion of the roentgenologist that this represented an intra-articular chip fracture.

After débridement, inspection showed that the laceration extended through the joint capsule just lateral to the patella. The fragment, which came from the marginal surface of the lateral condyle, was easily located. It was approximately three times the size anticipated from the roentgenogram (Fig. 1). The additional bulk was due to cartilage which comprised about three-fourths of the loose fragment. After removal of the fragment, the joint capsule was snugly closed with interrupted non-absorbable stitches.

The knee was aspirated on the second and third postoperative days. Bacterial cultures on both these occasions proved sterile. The patient made an uneventful recovery.

CASE 2. G. M., female, aged sixteen, was injured in a gymnasium class in February 1943. The local physician who attended the patient stated that the patella was dislocated, and there was a gross hemarthrosis, necessitating the aspiration of blood. Although the symptoms quickly became less acute, constant pain in the knee persisted, and locking occurred in flexion on six or seven occasions during the four months following the injury.

Examination of the knee, when the author first saw the patient four months after the initial injury, showed excess fluid in the joint with ballottement of the patella. Motion, both passive and active, was normal. The joint was stable. There was slight tenderness over the medial ligaments. Roentgenogram of the knee was negative (Fig. 2-A). The patient was advised to keep the knee mildly compressed with an elastic bandage, and to return at intervals for observation, as the episodes of locking made the examiner suspect a cartilage injury.

The patient was seen twice at intervals of two weeks, on both of which occasions she stated that

the pain still persisted. Tenderness could be easily elicited by pressing the patella against the femur. These further observations pointed toward chondromalacia of the patella or an internal derangement, in which either the infrapatellar fat pad or some other soft-tissue structure was interfering with adequate motion. Arthrotomy was advised. This was performed on July 23, 1943, the knee being opened through a medial parapatellar incision seven inches (17.5 centimeters) long. As soon as the joint had been opened, a large defect was seen in the articular cartilage in the medial half of the patella. This defect was irregular, and extended through the chondral portion of this bone. The defect had been filled in to some

FIG. 1

Case 1. Anteroposterior roentgenogram of knee. Arrows indicate the intra-articular osteochondral body derived from the lateral condyle of the femur.

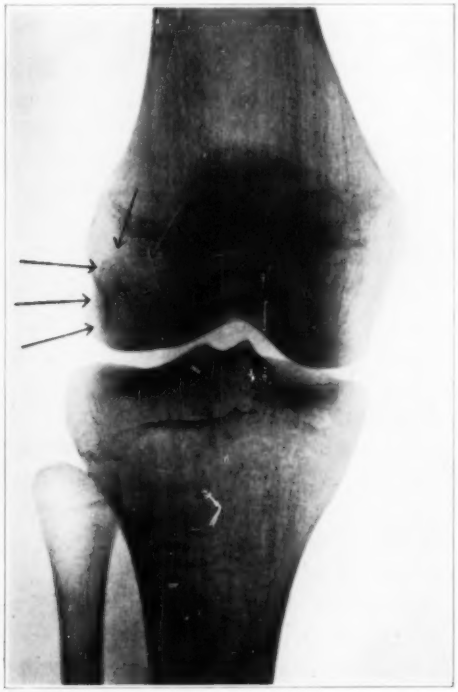

FIG. 2-A

Case 2. Anteroposterior roentgenogram of knee. The shadows of the osteochondral body are quite hazy, and they were identified only after the body was discovered at arthrotomy. The arrows indicate the position of the fragment.

FIG. 2-B

Views of the osteochondral loose body removed from knee in Case 2. Note the roughness on the posterior surface. This appearance is undoubtedly due to the irregular deposit of fibrin and fibrocartilage on the former bare osseous surface of this fragment.

extent with fibrocartilage. There was a corresponding groove in the cartilage of the medial femoral condyle, estimated to be one-eighth of an inch (0.3 centimeter) in depth, which had been produced by the constant friction of the irregular patellar surface. Further search in the joint demonstrated a single large cartilaginous fragment at the level of the lateral femoral condyle and firmly adherent, being bound down on the lateral aspect by numerous fibrous adhesions. The body (Fig. 2-B), when removed, resembled in size the cartilage defect in the medial half of the patella. After removal of the loose body, the groove in the medial femoral condyle was made smooth by paring the rough margins with the scalpel. The knee joint was closed in layers, and a plaster cylinder was applied, extending from the ankle to the junction of the middle and upper thirds of the thigh.

Reinspection of the roentgenogram (Fig. 2-A) taken before operation showed an indefinite shadow which partially overlay the lateral femoral condyle. This shadow was unquestionably due to the few osseous elements present in the detached fragment.

The postoperative course was uneventful; the patient left the Hospital on the fourth postoperative day, walking with the aid of crutches. Three weeks after the injury and ten days after removal of the plaster cylinder, she stated that her knee joint functioned better than at any time since the injury. The patient walked with a normal gait, and joint motion was normal. She was last seen one and one-half years after operation, and complications had not arisen.

DISCUSSION

The sequence of events and the operative findings leave little doubt that the intra-articular fracture was produced by the injury. In Case 1, the osteochondral fragment recovered fitted the defect; but, in Case 2, the bed of origin had been filled to some extent with fibrous tissues. Such an injury may be either direct, as occurred in Case 1, in which a stone or other sharp object penetrated the soft structures about the knee, and, in turn, injured the intra-articular structures; or the osteochondral fragment can be loosened from the patella indirectly by the trauma which had originally dislocated this structure. Since most dislocations of the patella occur in a lateral direction, it can be assumed that the lateral femoral condyle scooped the osteochondral fragment from the medial posterior aspect of the patella. The injury in either case was sharply localized.

Milgram speculated upon the possibility of a patellar dislocation producing the fractures which he described, but a clear-cut history of this occurrence was present in but one of his cases. Dislocation of the patella was confirmed in Case 2 both by the patient and by the referring physician.

The ability of the intra-articular structures to repair the defect can only be inferred in Case 1, where operation was done a few hours after the injury. Case 2, however, demonstrated the filling in of the bed of origin to about half its extent with fibrocartilage, which had formed in the five months which elapsed between the time of the original injury and the arthrotomy.

These cases bear no relation to the condition of chondromalacia of the patella, which is evidently a degenerative phenomenon affecting that bone. The experience in both of these cases would suggest that roentgenograms taken with the technique utilized for demonstration of soft-tissue shadows would reveal osteochondral fragments with greater regularity.

These cases have both been followed for sufficient periods (five years in Case 1, and two years in Case 2) to make it unlikely that there will be any recurrent disability in either joint.

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ACUTE SPONTANEOUS ABSORPTION OF BONE

Report of a Case Involving a Clavicle and a Scapula

BY MAJOR HIRA E. BRANCH

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Acute spontaneous absorption of bone is a rare and very striking disease. It has also been called "phantom" bone.

There have been a few case reports of acute spontaneous absorption of the metatarsals and of phantom metatarsals. Usually the metatarsal bone disappears gradually, leaving only fibrous tissue in its place.

In the literature only two reports were found, which in any way resembled the case to be reported here. The first was briefly narrated in *The Boston Medical and Surgical Journal* in July 1838, and was later quoted by Costello as "without parallel in the records of surgery". A complete history of this case was subsequently published.[1] In this early case a definite fracture of the humerus and a refracture occurred before bone absorption began. However, there was no fracture or unusual trauma in the case presented here.

The second case in the literature was one of progressive atrophy of the facial bones with complete atrophy of the mandible, reported by Thoma. However, the author felt that "the disease no doubt was initiated by dental infection", whereas in the case presented here there was no infection.

The writer has not seen a report describing this condition in the scapula or the clavicle, although a case was presented * some years ago at a meeting of the Clinical Orthopaedic Society in Cleveland, Ohio, at which the writer was present. The patient was a young woman with a phantom scapula who had been followed for five years, during which

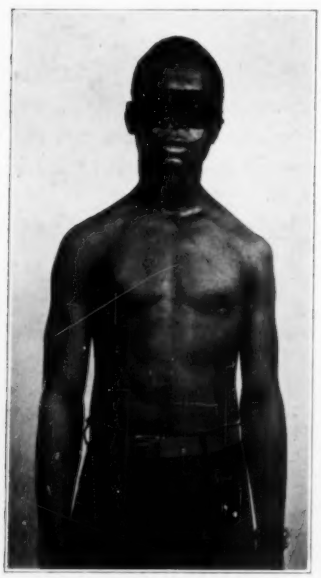

Fig. 1

Well-developed individual. Notice depression where outer two thirds of clavicle and acromion process should have been. The scar is from a biopsy.

Fig. 2

Lateral view showing depression where superior border of scapula should have been.

Fig. 3

Notice loss of shoulder motion, due to absence of acromion process and clavicle.

* The name of the physician who presented the case is not recalled.

time the entire scapula had gradually disappeared. Three biopsies had been taken during this time, and the bone had been completely replaced by fibrous tissue. All laboratory tests had been consistently negative.

CASE REPORT

A twenty-year-old colored soldier entered the Hospital June 3, 1944. He was well developed and well nourished, and had no complaints other than inability to raise his left arm above his head. He had had no symptoms until May 1944 when, during the ordinary duties of rifle drill at a nearby camp, he rolled over on the ground, and his rifle pressed against his left shoulder. After this he had noticed some pain and discomfort in the left shoulder region. Gradually he had become unable to raise his left arm above his head. He entered the Camp Station Hospital on May 18, 1944, where roentgenograms of the chest and left shoulder were taken. A tentative diagnosis was made of bone tumor, and he was transferred to the General Hospital on June 3, 1944. By this time his pain had disappeared, and he complained only of loss of arm motion (Fig. 3). The patient's past history and family history were entirely negative.

FIG. 4

Roentgenogram taken May 18, 1944. Note that inner third of left clavicle is present, but outer two thirds are gone. Notice fragments of superior border of scapula.

FIG. 5

Roentgenogram taken June 6, 1944. Note absence of clavicle, acromion process, and superior border of scapula. The neck of the scapula is disappearing.

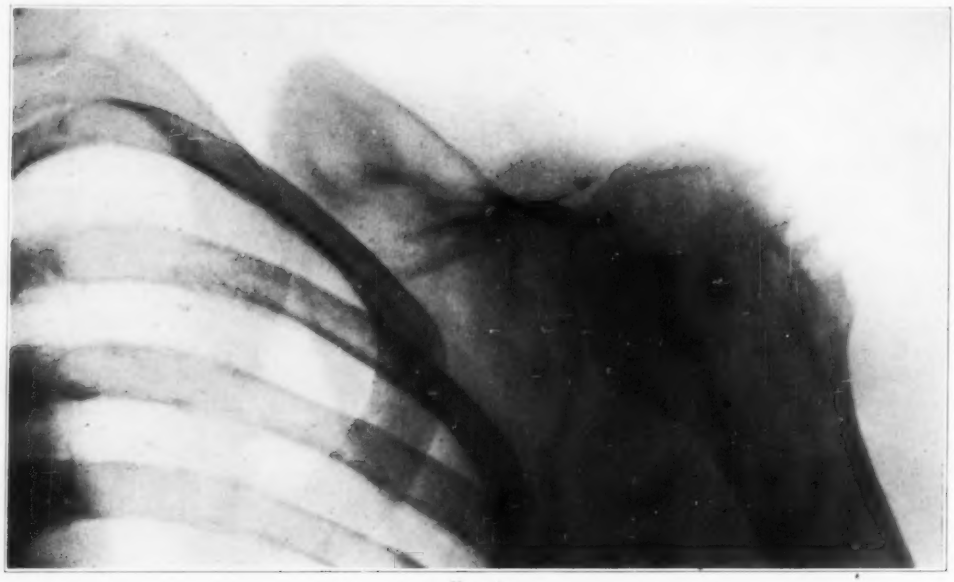

FIG. 6

Roentgenogram of left shoulder, September 11, 1944. There has been progressive absorption of clavicle, and upper portion of scapula.

In place of the left clavicle there was a depression, and mild crepitus was elicited in the upper scapular region. Arm motion was limited, but not painful. The head of the right humerus was slightly higher than the left. The rest of the examination was entirely negative.

Roentgenograms were reviewed, and revealed an absence of the outer two thirds of the left clavicle and absence of the superior border of the left scapula, involving the neck of the scapula.

Blood studies were normal, and the blood Kahn test was negative.

Red Blood Cells	4,700,000
Hemoglobin	14.2 grams per 100 cubic centimeters
White Blood Cells	6,600
Neutrophils	72 per cent.
Lymphocytes	28 per cent.
Blood calcium	9.7 milligrams per 100 cubic centimeters
Blood phosphorus	3.3 milligrams per 100 cubic centimeters
Blood phosphatase	3.7 Bodansky units

The urinalyses were normal. Roentgenographic studies of all other bones were normal. Pulmonary roentgenograms were normal, as were the gastro-intestinal studies. The kidney, urinary tract, and bladder studies were normal.

The diagnosis was phantom clavicle and scapula.

Exploration was carried out, and biopsies were taken on June 14, 1944. Grossly, only fibrous tissue was found where the clavicle should have been, and biopsy specimens under the microscope revealed only fibrous tissue. Biopsies were taken of the area of loose bone, where the superior border of the scapula should have been. Biopsy was also taken where the acromion process should have been.

PATHOLOGICAL REPORT *

"Sections taken through muscle, fat, and connective tissue [Fig. 7] show no evidence of any vascular inflammatory or neoplastic disease.

"Sections through what appeared to be the medulla of the bone showed almost complete absence of bone spicules. There are abundant remaining vascular channels from the medullary portion, and they contain red blood cells in scattered areas. Outside of these channels there is a small amount of hematopoietic tissue. There is only one area showing the presence of fibrosis. There is no evidence of an inflammatory or neoplastic process in these sections.

"Sections through actual bone [Fig. 8] show the presence of many well-formed spicules. There are definite areas of degeneration in the bone with presence of osteoclasts and localized fibrosis. At the junction of bone and cartilage, there is an irregular area of osteoid tissue as well as fibrosis.

* For this report the author is indebted to Lt. Col. Stuart W. Lippincott, Pathologist.

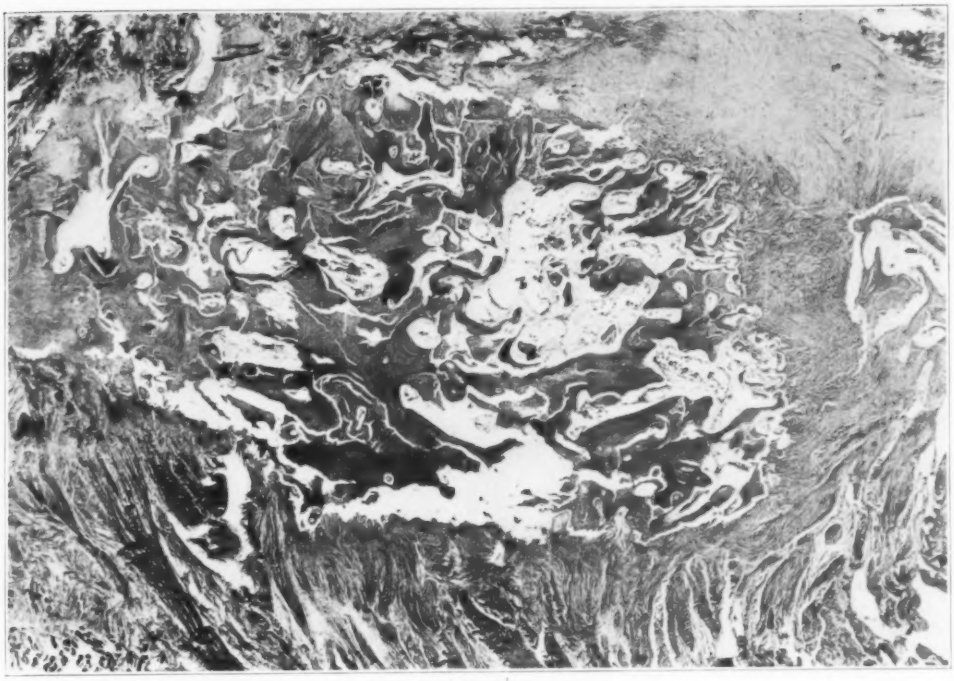

FIG. 7

Photomicrograph (× 16) of section through area which should have been medulla of the clavicle. (*U. S. Army Medical Museum Neg. No. 89408*)

FIG. 8

Photomicrograph (× 104) of section through actual bone of the scapula at the edge of the degenerative process. (*U. S. Army Medical Museum Neg. No. 89407*)

"The pathological changes in the bone are those of a strictly degenerative character with fibrosis. There is no evidence of an inflammatory or neoplastic lesion."

PROGRESS

After a period of six months, absorption of the clavicle, the scapula, and the neck of the scapula had progressed. The patient was without symptoms, except for loss of abduction of the arm. Pulmonary roentgenograms were normal.

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CLAVICULAR DYSOSTOSIS

A Case Report

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The clavicle, which is the first bone in the body to ossify, is occasionally the site of developmental anomalies; these maldevelopments may be associated with changes in the skull, the syndrome of hereditary cleidocranial dysostosis [2] described by Marie and Sainton in 1897. More rarely the clavicle alone is affected, although the disease may appear in one or both clavicles and take the form of underdevelopment of the central part of the collar bone, especially of the outer half.

E. D., a Second Radio Officer T124T, aged eighteen, during a routine examination was noticed to have an unduly prominent inner end to his right clavicle, with an apparent loss of bone lateral to the clavicle. Inquiry revealed that this anomaly had been present since birth, and that his sister was similarly affected. There was no other abnormality of development; and, as far as he was aware, the rest of his family was quite normal. Inspection revealed a well-developed inner half of the clavicle, which was mobile; the outer half was barely palpable, being short and rotated downward and inward. Roentgenograms showed the clavicle to be in two parts, the adjacent ends being covered with cortical bone, and having smooth, rounded contours (Figs. 1-A and 1-B). This officer suffered no inconvenience from the defect; his shoulder girdle was strong and stable, although the condition in the middle of the collar bone amounted to a pseudarthrosis. Unfortunately, it was not practicable to obtain roentgenograms of the other members of his family.

An almost identical condition has recently been recorded, affecting the right clavicle in a mother and her two daughters.[4]

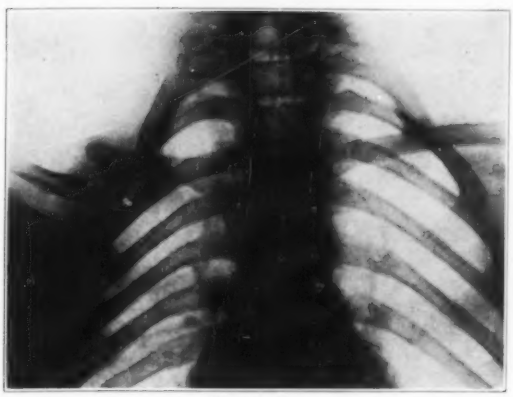

FIG. 1-A

FIG. 1-B

The ossification of the clavicle has been the subject of much anatomical discussion.[1,3] Briefly it is preceded by a condensation of connective tissue in the form of a rod, in which two centers appear near the mid-point at the sixth week of intra-uterine life. Ossification proceeds from these two centers, and presumably it is the failure of these to fuse which leads to the dysostosis. A secondary center appears in cartilage at the sternal end about the twentieth year; it is extremely thin and fuses with the body at the age of twenty-five. The collar bone thus develops mainly from membranous or precartilaginous centers, and it is the association of these anomalies with those of other bones of similar origin, in the skull, which has led to the suggestion that these dystrophies are solely membranous.

NOTE: The author is indebted to the Medical Director General of the Navy, Vice-Admiral Sir Sheldon Dudley, for permission to publish this case report.

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CONGENITAL HUMERORADIAL SYNOSTOSIS

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AND
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Congenital humeroradial synostosis is an extremely rare abnormality, and the writers feel that the addition of this case to those already described would be of some interest. Up to the present time, some twenty-four cases have been reported, nearly all of them in the European literature.

It is apparent that there is an hereditary tendency in cases of this kind, since the deformity has been reported in several siblings. Frostad reported five cases, all involving both elbow joints; three cases occurred in one family, and two in another family. He points out what types of work these people could do in spite of the deformity. For example, one was a farmer, one a tailor, and another a housemaid. These people had been able to do their work quite satisfactorily, but they were dependent upon others for several of their personal needs. The author mentions that the patients could not touch the backs of their heads, tie their neckties, button clothing over their chests, or perform other equally difficult motions. Some patients found it awkward to feed themselves. Writing was difficult, because the pronated position of the hand caused the volar surface to rest on the desk. However, most of these people led useful, active lives, one being seventy-two years old at the time of Frostad's report.

Frankel reported four children in one family, who had congenital humeroradial synostosis. He feels that only an hereditary factor could cause this familial and congenital abnormality. He points out that, because of the absence of an hereditary disposition to the deformity in this particular family, a germinal change may have taken place in one of the parents, leading to the production of new characteristics. He suggests that the new characteristics may have appeared as a result of a "germinal rearrangement". A person who possesses a rare dominant condition nearly always possesses the determining gene in one chromosome only. The theory of genetics demands that half of such a person's offspring, provided he is married to a normal person, will have the dominant trait. Therefore, Frankel points out that, because of the rarity of the abnormal condition, and the absence of consanguineous marriages in this family, it is unlikely to be caused by recessive hereditary factors. It is generally assumed that if two parents are carriers, only one fourth of their offspring will show the recessive trait.

A case of a farmer, twenty-one years old, whose involvement was in one elbow only, was reported by Romanus.

Acuña and Puglisi feel that the anomaly may be due to endogenous causes.

The only reported attempt at surgery for this condition was made by Mouchet and Saint-Pierre on a boy who had a bilateral deformity. The ankylosis was sectioned, the extremities were shaped to form a joint, and a musculo-aponeurotic flap was inserted to prevent another ankylosis. Unfortunately, they do not report the results in this case, and attempts to communicate with them recently have been unsuccessful.

CASE REPORT

Mrs. C. D., white, aged twenty-four, was admitted to the Rahway Hospital on September 13, 1944, at term in her second pregnancy. She had one other child, a boy two and a half years old, living and well and showing no deformities. There had been no deformities in the family for three generations, and no consanguineous marriages. The blood Wassermann was negative, and the blood count was normal. The mother had received apparently normal dosages of a multi-vitamin preparation during the pregnancy. Her course during the pregnancy had been entirely normal, and her physical condition was

FIG. 1

normal. On September 14, 1944, she gave birth to a female, weighing five pounds. It was soon noticed that the baby's elbows were flexed at slightly less than 90 degrees, and all attempts to straighten them were unsuccessful. Roentgenograms (Fig. 1) showed that there was no articulation at all at the elbow; the radius and the humerus were one continuous bone. There was also some deformity of the left clavicle. The child's general condition has since been entirely normal. Surgery to correct the deformity has been considered, but the authors do not feel that it holds much promise.

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CONGENITAL ABSENCE OF THE ODONTOID PROCESS

A Case Report

BY CAPTAIN RAYMOND C. SCANNELL

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Congenital absence of the odontoid process from the cervical axis has been reported in one case by Roberts and in two cases by Weiler. Absence of the odontoid as an attachment for ligaments and as a support for the atlas suggests the likelihood of instability in the atlanto-axial joint. All of the previously recognized cases came under observation because of dislocation of the atlas on the axis. In the author's case here presented, the patient's first symptoms were in his neck, because of an injury in which the integrity of the atlanto-axial joint was involved.

CASE REPORT

This patient, a twenty-three-year-old soldier, suffered sharp pain in the neck after a twist, sustained while wrestling on March 10, 1944. The pain was accompanied by generalized weakness, most noticeable in the arms. During the half hour following injury, the weakness gradually disappeared.

The patient received his first examination and treatment elsewhere. He reported a roentgenographic examination, application of traction for one week, and return to duty after a period of observation.

With the persistence of ill-defined complaints in the entire body, he again came under medical observation on July 5, 1944. He failed to improve, and was transferred to a General Hospital, where he first came under the writer's observation. The patient carried his head stiffly, and neck motion was limited, particularly extension. Physical findings were otherwise normal, except for a strabismus and a mild hyperhidrosis of the feet. Laboratory studies were all within normal limits. Roentgenographic studies, including laminagrams, revealed a complete absence of the odontoid process, and abnormal mobility of the atlas on the axis in flexion and extension.

Fig. 1-A

Lateral view of the cervical spine with the neck in extension.

Fig. 1-B

Lateral view of the cervical spine with the neck in flexion. Comparison with Fig. 1-A demonstrates abnormal mobility of atlas on axis.

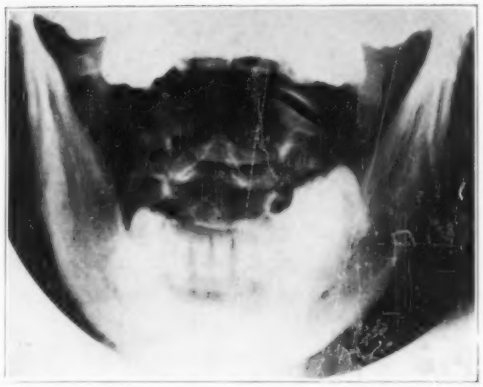

FIG. 2

No evidence of the odontoid process is noted in an open-mouth anteroposterior view. Some displacement of the first cervical vertebra on the second is present, and was noted in all anteroposterior views.

FIG. 3

Laminagraphic section through level of odontoid region.

Immobilization of the neck failed to relieve the patient's complaints. While under our observation, there was at no time objective evidence of cord damage. The soldier was considered physically unfit for further military service, and was, therefore, discharged. He desired no other treatment.

COMMENT

From a mechanical standpoint, instability of the atlas on the axis is to be expected in congenital absence of the odontoid process. This is borne out by the occurrence of atlanto-axial dislocation or subluxation in the cases of congenital absence of the odontoid, reported in the literature. Consideration of possible absence of the odontoid in diagnosis of atlanto-axial dislocation or subluxation, and a careful technique, in roentgenographic examination of upper cervical injuries, including laminagrams, are suggested. Weiler describes a fusion which he used successfully in his first case, and contemplated for his second.

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AVULSION FRACTURE OF THE ISCHIAL TUBEROSITY

A Case Report

BY CHARLES C. ABBATE, M.D., LODI, NEW JERSEY

Avulsion fracture of the ischial tuberosity may occur occasionally in individuals in whom the tuberosity has not become firmly united. In 1912, Berry [1] reported a case in England in which the fragment was removed surgically, and the condition has occasionally been reported since that time.[2,4,5,6] The patient's history usually reveals that the hamstrings, while taut, were subjected to excessive strain. The direction and the degree of displacement of the ischial tuberosity depends upon the action of the various muscles attached to the tuberosity. Thus the hamstrings pull downward, forward, and outward; the adductor magnus and quadratus femoris forward, outward, and downward; while the sacrotuberous ligament, the primary antagonistic force, resists downward and outward displacement.

The following case report illustrates the manner in which fracture is produced:

The patient, at the age of sixteen, stepped on a stone while running a race, lost his balance, and fell. Roentgenograms were not made, and he was treated by rest, local heat, and massage. At the time of the accident, walking produced moderately severe pain in the region of the tuberosity, radiating down the hamstrings. This pain subsided after three or four weeks, but the patient found that any excess of walking or running precipitated an episode of pain, so that he had to discontinue his track work. For six years after the original injury he had frequent bouts of pain when the related muscles were exerted. Treatment with heat and rest produced symptomatic improvement.

At the age of twenty-two, the patient sought treatment for a boring pain in the region of the left ischial tuberosity and hamstrings, which was aggravated by rising after prolonged sitting, or by sitting

FIG. 1

after he had been on his feet for any length of time. Roentgenogram (Fig. 1) showed an old avulsion fracture of the left ischial tuberosity in which there was considerable callus formation. Because of this union, and because the degree of disability was slight, conservative therapy was adhered to. Treatment consisting of rest, local heat, and the injection of procaine in oil around the callus proved adequate, although there were several recurrences of pain. The patient is now relatively free from symptoms, and occasional pain is treated with heat and rest.

Operative treatment has been recommended for this condition only if pain and disability have persisted. In such cases, the examiner may be able to elicit tenderness over the ischial tuberosity, and a poorly defined nodular mass may be felt. It then becomes necessary to extirpate the bony mass, usually by the perineal route.

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UNILATERAL CONGENITAL CALCANEOCUBOID SYNOSTOSIS WITH COMPLETE ABSENCE OF A METATARSAL AND TOE

A Case Report

BY CAPTAIN LEONARD C. VENERUSO

Medical Corps, Army of the United States

From Station Hospital, Scott Field, Illinois

Wagoner, Bargellini, and Mahaffey have reported congenital fusion of the calcaneocuboid joint, unassociated with other congenital abnormality of the bones of the foot. Holland has reported calcaneocuboid synostosis with fusion of the middle cuneiform to the second metatarsal, and of the external cuneiform to the third metatarsal. Illievitz has reported unilateral absence of one toe with talonavicular fusion. Talonavicular fusion has also been reported by Lapidus and by O'Donoghue and Sell.

CASE REPORT

A twenty-two-year-old white male was seen in the Orthopaedic Clinic of the Station Hospital, Scott Field, complaining of pain along the inner border of his right foot, aggravated by prolonged walking or

FIG. 1-A

FIG. 1-B

standing. He attributed this to the fact that he was "born with only four toes on this foot". There was no history of any other member of his family having a similar condition.

At the time of examination, the patient was wearing a size 8½-D shoe on his left foot, and a size 7-D shoe on his right foot (Government-issue low-quarter shoes).

The left foot presented no abnormalities. The right foot was somewhat smaller than the left, showed a mild pes cavus, and had only four toes. The large toe on this foot was normal in size, but the other toes were larger than the corresponding toes of the left foot. Motions of the left foot were of normal range. There was slight limitation of inversion and eversion of the right foot, but the other motions were normal.

Roentgenograms were taken of both feet. The left foot showed no abnormalities. The right foot (Figs. 1-A and 1-B) revealed the complete absence of one metatarsal and its phalanges, and a fusion of the calcaneus and the cuboid bones. No evidence of a joint line between these bones could be found, and there was continuity of normal bone structure throughout.

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TRAUMATIC DEGENERATION OF THE MEDIAL HEAD OF THE GASTROCNEMIUS SIMULATING A SEMIMEMBRANOSUS BURSA

A Case Report

BY HAROLD H. COHEN, M.D., NEW YORK, N. Y.

From the Beth David Hospital, New York

The following case report is presented, both because of the rarity of the condition and the unexpected operative findings.

D. M., a man thirty-nine years old, while standing on a truck, lost his balance, and fell heavily upon the posterior aspect of the extended left knee. He arose unassisted, and continued work despite the immediate onset of pain. This accident occurred on May 23, 1944, and the patient did not seek medical attention until June 15, applying home remedies during the interval. On June 15 physical therapy was begun. He was first seen by the writer on July 18, and he complained at that time of pain in the back of the left knee, especially upon bearing weight, and toward the end of a day's work. There was frequent buckling of the knee, especially upon rising from the seated position.

FIG. 1

Photograph of specimen removed from medial head of gastrocnemius. This measured 6 by 3.5 centimeters, was grayish-yellow in color, and rather firm in consistency.

The patient's past history was irrelevant. Physical examination revealed a muscular, well nourished, adult male, five feet six and a half inches tall, and weighing 155 pounds. He walked with a slight left-leg limp, with the aid of an elastic knee support. There were moderate varicose veins over both legs. The anterior aspect of the left knee presented normal markings, with no evidence of synovial effusion or thickening. There was no atrophy of the quadriceps. The popliteal space revealed a globular swelling, cystic in character, measuring four by four centimeters, and overlying the semimembranosus muscle. This "tumor" was most clearly visualized in the erect or prone position with the knee in complete extension. When the knee was flexed, the mass became smaller, but was still palpable, and did not empty into the knee joint. The skin overlying the swelling was freely movable, while the mass itself was not attached to the underlying tissues. The mass was tender to the touch. There were no other points of tenderness. Stability of the knee was not impaired, either in the anteroposterior or the lateral direction. Motion was only slightly restricted in flexion, while extension was complete. There was no palpable enlargement of the inguinal glands. The peripheral circulation of the limb was intact, and no bruit was discernible. Roentgenographic examination of the knee joint failed to reveal evidence of an osseous lesion. A diagnosis of a semimembranosus bursa was made, and excision was advised.

The patient was again seen on August 23, when essentially the same findings were noted. Operation was again advised, and was finally carried out on October 10.

OPERATIVE TECHNIQUE

Through a slightly curved six-inch (15-centimeter) incision over the cystic swelling, the superficial and deep fascia were incised. The semimembranosus muscle and the semitendinosus tendon readily came

FIG. 2

Photomicrograph (low-power view) of section of specimen, illustrating extensive fatty-tissue replacement of striated muscle fibers.

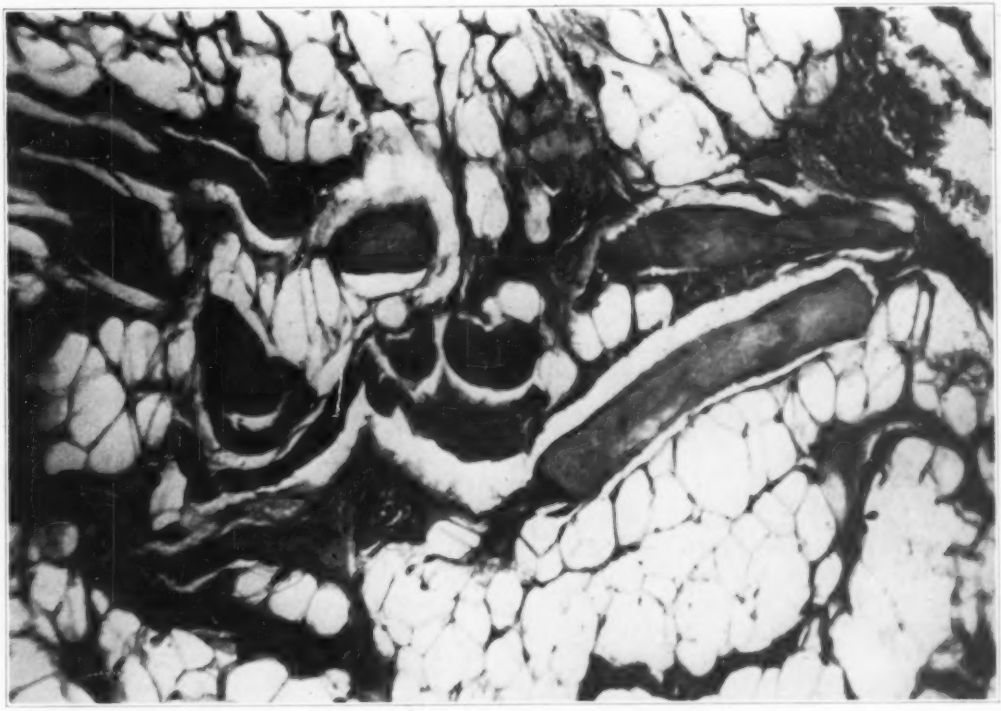

FIG. 3

Photomicrograph (high-power view) of extreme left corner of Fig. 2, illustrating muscle degeneration and atrophy with fatty-tissue replacement.

into view. On retraction of the semimembranosus, a large globular swelling, about the size of a small orange, and involving the medial gastrocnemius, was noted. The neurovascular bundle was pushed laterally, resting over the lateral gastrocnemius. A longitudinal tear was found, extending through the fibrotendinous margin of the medial head of the gastrocnemius. Examination of the cystic swelling through this hole revealed soft fibro-fatty material. The roof of the swelling was incised, and after a thinned-out layer of the medial head of the gastrocnemius had been spread apart, a considerable quantity of fibro-fatty tissue welled up from the depths of the belly of the muscle (Fig. 1). There was no definite capsule visible. The entire mass was excised, removing as much surrounding muscle fiber as was feasible. The material shelled out rather easily, and very little bleeding was encountered during its removal. Closure of the muscle defect was then performed by several interrupted plain catgut sutures. The deep and superficial fascia were closed in layers with interrupted No. 1 chromic catgut sutures, and the skin was closed by means of continuous black silk sutures. A tight compression bandage was applied. The postoperative course was uneventful. The patient made a complete functional recovery.

PATHOLOGICAL REPORT

The specimen consisted of an irregular mass of tissue, measuring 6 centimeters in length and 3.5 centimeters in width. The surface was grayish-yellow in color. The mass was rather firm in consistency. In the section, yellowish fat globules were visible. The intervening tissue consisted of grayish-pink firm strands. Some of the peripheral areas showed small grayish-pink fibers which grossly resembled muscle (Fig. 1).

The microscopic section revealed striated muscle tissue, in which degeneration and atrophy had taken place, with extensive fatty replacement. There was no evidence of malignant degeneration or infection (Figs. 2 and 3).

COMMENT

Although the pathogenesis is not clear, the influence of trauma cannot be denied. It would seem that the sudden application of the patient's body weight upon the extended knee caused a deep rupture within the muscle belly of the medial head of the gastrocnemius, with secondary degeneration and fatty-tissue replacement. However, the absence of microscopic hemorrhages or hemosiderin would appear to vitiate this view. It seems more likely that nerve or vascular damage resulted in infarction with fibrillar degeneration and fatty-tissue replacement. That the lesion is not a lipoma is clearly seen in the microscopic studies (sections taken from the center of the specimen), which reveal fatty tissue, and degeneration and atrophy of muscle fibers throughout. Infection and malignant degeneration were also ruled out by the operative and pathological findings. It is also interesting to note the absence of calcification within the fatty degenerated muscle, despite the fact that operation was delayed for five months after the initial trauma, and good soil for deposition of calcium was present. Apparently this case does not fall into the group designated as myositis ossificans circumscripta.

CORRECTION

Dr. Raphael R. Goldenberg, of Paterson, New Jersey, has requested that acknowledgment be made that he was in error in including the reference to Watson-Jones in his article, "Closed Manipulation for the Reduction of Fractures of the Neck of the Radius in Children", published in *The Journal* for April 1945 (XXVII, 267). The opening sentence of his article reads: "In the treatment of fractures of the neck of the radius in children, where the displacement is marked, many authorities [reference numbers] believe that only two methods are likely to give satisfactory results,—either excision of the capital fragment or open reduction." Sir Reginald Watson-Jones should not have been included as one of these authorities.

INSTRUMENT FOR ACCURATE MEASUREMENT OF BONE SCREWS

BY MAJOR JOHN J. FLANAGAN
Medical Corps, Army of the United States

In measuring bone depth some time is spent, and occasionally difficulty is experienced, in determining the accurate depth for the insertion of bone screws of proper length. This is true both in the use of bone grafts and of plates employing screws for fixation. While, to assure good fixation, it is necessary to engage the deep cortex, as well as the proximal, penetration of the neighboring soft tissues by the screw tips is undesirable.

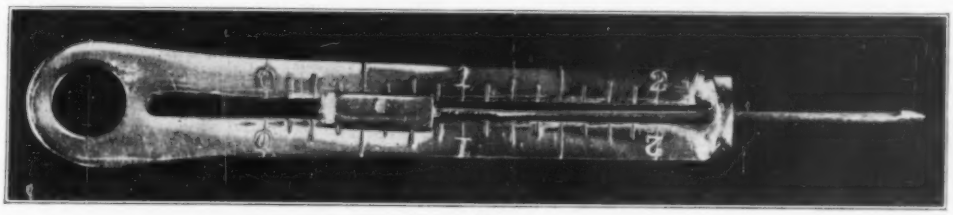

FIG. 1
Instrument open.

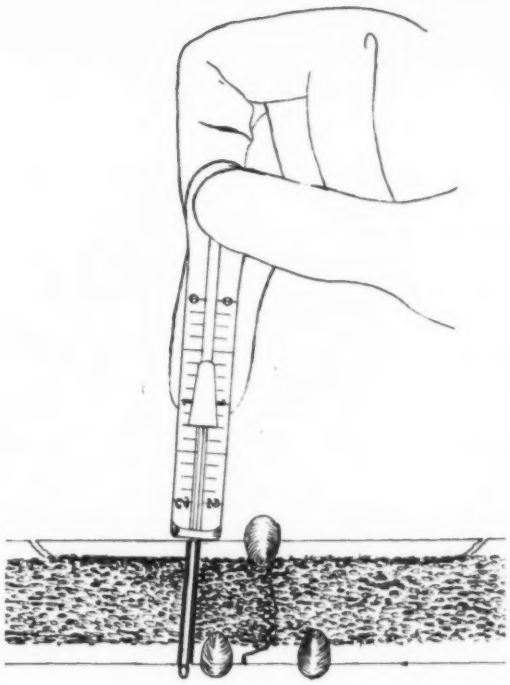

FIG. 2-A
Instrument in use, front view.

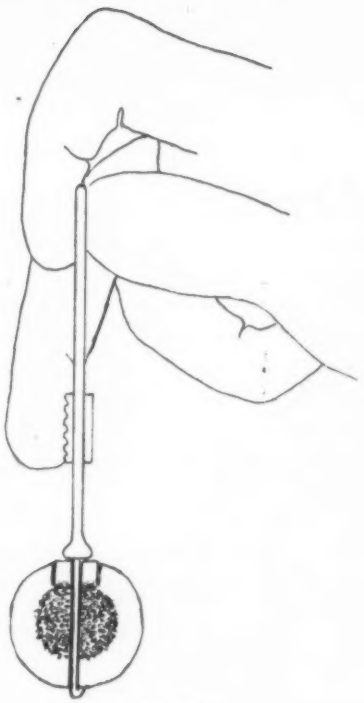

FIG. 2-B
Instrument in use, side view.

The measuring instrument * pictured consists of a sliding rod with terminal hook, which is passed through the drill hole, and engages the deep cortex. The caliber of the sliding rod and hook is less than that of the standard drill hole. The depth is accurately revealed in fractions of an inch on a calibrated scale on the face of the instrument, by means of a marker connected with the proximal end of the sliding rod.

The drawings reveal the instrument in use. It is small and compact, and fits readily into small or deep wounds. It obviates the risk of undermining the soft tissues beyond the deep cortex, while determining accurate depth.

* Designed in the Orthopaedic Instrument and Brace Shop of the Kennedy General Hospital.

A CAST-CALIPER BRACE FOR IMMOBILIZATION OF THE HIP

BY MAJOR GEORGE S. PHALEN

Medical Corps, Army of the United States

In the treatment of War casualties at an Army General Hospital, we have been impressed with the relative frequency of compound fractures involving the acetabulum and the head and the neck of the femur. Many of these fractures are complicated by the development of suppurative arthritis of the hip joint, as well as by chronic osteomyelitis of the acetabulum and the femur. Despite the use of penicillin and the sulfonamides, combined with adequate surgical care, drainage sometimes continues for many months. Cultures of the wounds in these patients usually reveal a penicillin-resistant organism of the *Proteus* group; and in many cases pure cultures of these organisms are obtained.

When the hip joint is involved in a suppurative process, it is necessary to immobilize the joint in order to eliminate pain and prevent the development of deformities. This is best accomplished, of course, by a hip-spica cast; but the encasement of a lower extremity in a plaster cast for a period of several months is certain to result in varying degrees of fibrous ankylosis of the knee and ankle, even though these joints may not have been traumatized at the time the hip was injured. It is the mobilization of these joints, after removal of the cast, that unduly prolongs the patient's period of disability.

Caliper braces with pelvic bands or body corsets, which are used to immobilize the hip, are expensive to build, uncomfortable to wear both day and night, and do not readily

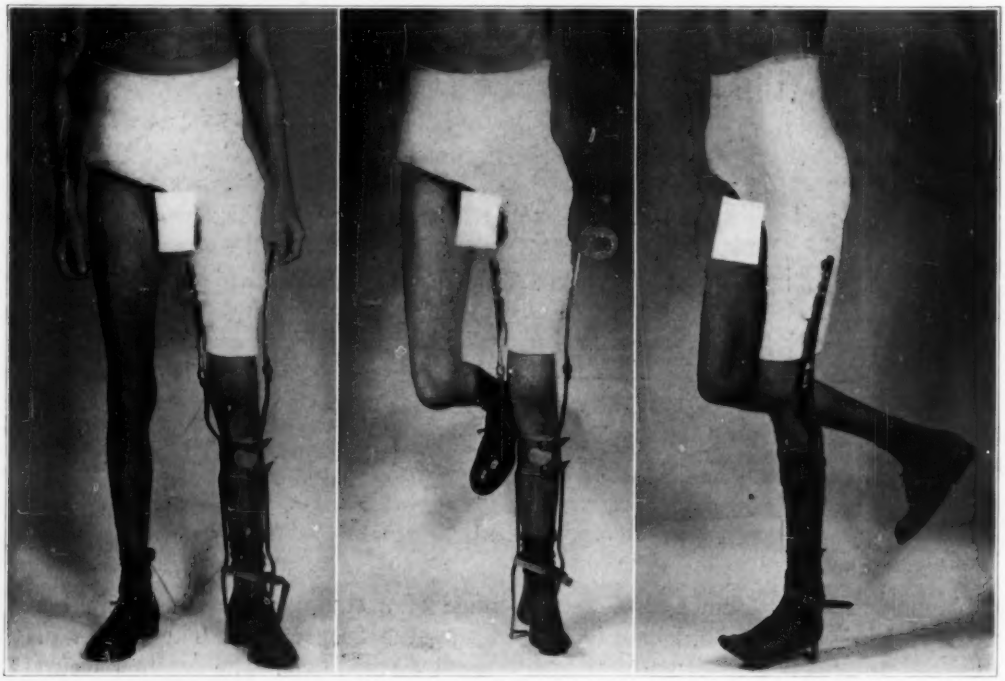

FIG. 1-A FIG. 1-B FIG. 1-C

Fig. 1-A: A soldier patient, wearing the cast-caliper brace to immobilize the left hip. He sustained a compound fracture through the acetabulum and head of the femur, when wounded in action by a machine-gun bullet. A chronic suppurative osteomyelitis developed, which necessitated prolonged immobilization of the hip joint.

Fig. 1-B and Fig. 1-C: Front and side views of the same patient, bearing his weight on the left leg with shoe removed from the caliper attachment. When the short spica cast is snugly applied, the cast-caliper brace serves adequately as a non-weight-bearing brace.

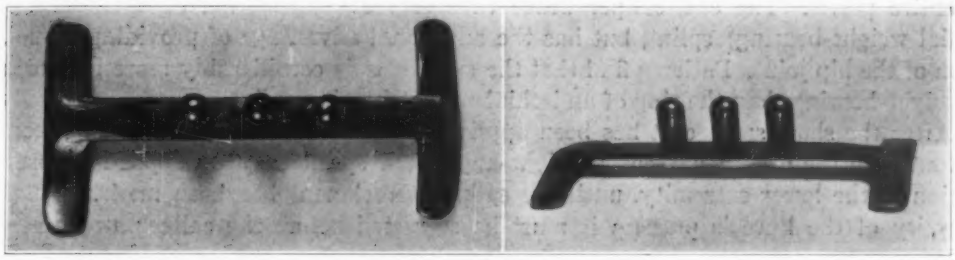

FIG. 2

Front and side views of the metal inserts employed to attach the caliper portion of the brace to the short spica cast. These insert bars measure approximately five inches in length.

permit dressing or irrigation of the wounds about the hip. The disadvantages of these braces have been overcome by the use of a single short hip-spica cast, into which is incorporated a long-leg-caliper attachment (Fig. 1-A).

A short, snugly fitting hip spica is applied, which includes the lower thorax, and extends to the knee. It is essential to non-weight-bearing that the cast be molded accurately about the pelvis and the ilia, firmly below the crests. Two metal inserts are incorporated in the leg portion of the cast. These inserts (Fig. 2) are fitted with three bolts, spaced five-eighths of an inch apart, to which the caliper brace is fastened. By means of these inserts, it is possible to adjust the length of the caliper attachment. This caliper attachment is fitted with hinges at the knee, with a stop to prevent extension beyond 180 degrees, and with drop-lock keepers, to hold the joint in complete extension, when the patient is ambulatory.

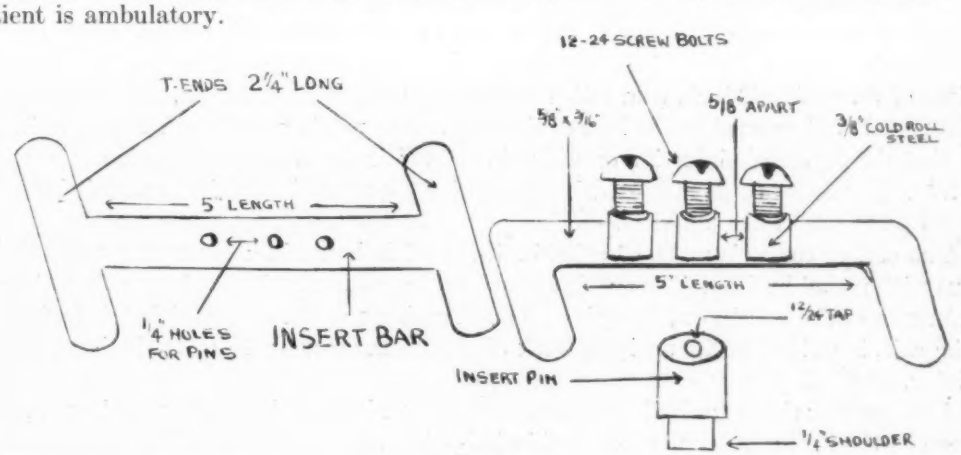

FIG. 3

Diagram of the insert bars to which the caliper portion of the brace is attached.

The caliper attachment is fitted into a tube in the heel of the shoe. Although the shoe may be readily removed, it is necessary to wear it both day and night, to prevent rotation of the leg. On occasion, the shoe may be left off at night, and the lower leg bound snugly against the caliper uprights with elastic bandages, in order to prevent external rotation of the lower extremity.

A window may be cut in the spica cast to permit daily dressing or irrigation of draining sinuses about the hip joint. If care is taken to prevent soiling of the cast by the drainage, such a cast may be left on a patient for at least twelve weeks; and then, if necessary, another similar cast may be applied, and the same long-leg-caliper attachment inserted into it.

This cast-caliper brace may serve adequately as a non-weight-bearing splint, by adjusting the length of the caliper attachment. The weight thrust upon the involved lower extremity is transmitted by the caliper uprights onto the short spica cast, which encases

the entire pelvis. The cast-caliper brace thus serves the function of a Thomas ring (ischial weight-bearing) splint, but has the additional advantage of providing immobilization of the hip joint. Patients find that the spica cast is considerably more comfortable for weight-bearing than the ring of an ischial weight-bearing splint.

After the short spica cast has been applied, and the two metal inserts have been incorporated in the cast, a non-rotary, right-angle foot splint may be applied to prevent rotation of the lower extremity, until the caliper attachment has been made. If flexion deformity of the knee is present, it must be corrected before the caliper attachment is applied.

Physical therapy is started as soon as the spica cast has been applied; these treatments consist of heat, massage, gentle forcing of the knee and ankle, and active and passive exercises involving the muscles which move the knee, ankle, and foot. The caliper attachment may even be removed daily, if desired, prior to the treatment, provided the necessary care is taken to prevent rotation of the lower leg.

CONSTRUCTION OF BRACE

Two bars are cut from five-eighth-inch by three-sixteenth-inch strips of flat surgical steel for each side upright. These are hinged together by a lap hinge with a stop to prevent extension beyond 180 degrees, and with drop-lock keepers, made of one-eighth-inch by three-quarter-inch strap steel. This knee hinge is placed just distal to the center of the knee, with the patient lying down. Five holes, seven thirty-seconds of an inch in diameter and five-eighths of an inch apart, are drilled into the portion of each upright above the knee hinge, starting one inch from the top. The upright bars are bent cold to conform to the contour of the leg. The lower end of each upright is drilled, and a section of quarter-inch rod is welded into these holes to fit into the tube in the heel of the shoe. A piece of three-eighth-inch, cold rolled steel rod is cut to proper length, welded to a piece of flat metal, and secured to the heel of the shoe. The rod is set at such an angle in the shoe that the degree of abduction or adduction of the foot will be the same as of the opposite foot. The ends of this rod are drilled out with a quarter-inch drill to permit insertion of the lower ends of the uprights.

The cuff or corset is made of calfskin, lined with horsehide; there are two elkhide straps with nickel buckles. The cuff is cut one and one-quarter inches larger than the circumference of the calf in order to give an overlapping tongue. A metal band, molded to fit the calf, is welded to the uprights back of the leather corset; the corset is riveted to the uprights.

Low-quarter shoes (oxfords) are usually employed. Occasionally it may be necessary to remove the heel counter to prevent skin irritation over a hypersensitive or an anaesthetic heel. In cases of foot-drop, a spring-toe attachment may be applied to the caliper brace.

NOTE: Credit is due Mr. Donald Salmon, Chief Orthopaedic Mechanic at O'Reilly General Hospital, for his assistance in the planning and building of this cast-caliper brace.

News Notes

THE AMERICAN ACADEMY OF ORTHOPAEDIC SURGEONS

The Thirteenth Annual Convention of The American Academy of Orthopaedic Surgeons will be held at the Palmer House, Chicago, January 20 to 23, 1946.

The Instructional Course Program, starting Saturday morning, January 19, will be similar to that planned for the 1945 Meeting (See *The Journal*, XXVI, 842, 843, October 1944). Motion pictures will be presented Saturday afternoon, and the Instructional Section Dinner, with an interesting program following, will be held Saturday evening.

POSTGRADUATE TRAINING IN ORTHOPAEDIC SURGERY

A joint committee of The American Orthopaedic Association and The American Academy of Orthopaedic Surgeons was organized in December 1944, to study the problem of postgraduate training in orthopaedic surgery, and particularly the problem of postwar training for the men in the military services who will, upon completion of their service, need some additional training in order to complete their requirements for certification by The American Board of Orthopaedic Surgery. The formation of this Committee was the outgrowth of numerous discussions among members of the Committee on Postgraduate Training in Orthopaedic Surgery of The American Academy of Orthopaedic Surgeons, members of the Executive Committees of each of the two societies named above, and members of The American Board of Orthopaedic Surgery. Doctor Guy Caldwell, Secretary of The Board, had on numerous occasions pointed out the importance of further developments in the training of men wishing to specialize in orthopaedic surgery.

The training of an orthopaedic surgeon should be along three definite lines: adult orthopaedic surgery, orthopaedic surgery for children, and the surgery of trauma, particularly fractures. It has seemed to the Committee that its main purpose is to encourage the development of centers to cover these three types of training. It was obvious that no adequate survey of the facilities in the country was available. With the aid of men named to report on various sections of the country, the survey has been completed.

The survey shows several things of importance: First, many services which have been important training centers for orthopaedic surgeons are at present not able to train men. Others cannot train as many men as they were able to before the War. The reasons for this are obvious. Many of the visiting men are in the Service, and, due to the quotas of Procurement and Assignment, the number of residencies in most institutions has been curtailed. Second, there have been several institutions which have applied to the Council on Medical Education and Hospitals of the American Medical Association for certification as centers for training in orthopaedic surgery. The Council is covering them as rapidly as possible, and the result of the survey will add a number of institutions to the accredited list. Third, there are a good many places where the material for proper training of orthopaedic surgeons exists, and the men who can conduct such training are available, but for one reason or another the establishment of accredited services has never been carried out.

This Committee feels that its first effort should be directed toward encouraging the organization and certification of services all over the country, where the facilities seem adequate and the men in charge are capable of training orthopaedic surgeons. It is the intention of the Committee to cooperate as closely as possible with the Council on Medical Education and Hospitals of the American Medical Association in order to bring about the certification of such services as seem adequate. It is not the purpose of the Committee, nor has it any authorization, to certify services for orthopaedic training.

In many instances, men returning from the Armed Services to civil life will want additional training of a special type. It is the hope of the Committee that arrangements can be made to satisfy the needs of each and every man as he comes back to civil life, so far as this type of training can be obtained.

Many of the readers of *The Journal* have been approached through this Committee or those aiding in this survey. Many will be in correspondence with the Committee about future plans. A widespread interest in the program has been shown. It is hoped that everyone concerned will feel it his duty to put forth the utmost effort to make this program a success.

The Committee is composed of the following members: Philip D. Wilson, M.D., James S. Speed, M.D., Fremont A. Chandler, M.D., Paul C. Colonna, M.D., Guy W. Leadbetter, M.D., and Ralph K. Ghormley, M.D., Chairman.

THE INTER-AMERICAN ORTHOPAEDIC FELLOWSHIP PROGRAM

The Inter-American Orthopaedic Fellowship Program, directed by the committee of orthopaedic surgeons appointed from The American Academy of Orthopaedic Surgeons and The American Orthopaedic Association, has been functioning for more than a year and a half. The financial support of the program comes from the W. K. Kellogg Foundation, and the Foundation confers with the Directing Committee on all matters of policy.

The Institute of International Education, New York, whose staff have had long experience in dealing with foreign students, both in this country and through its Committees on Selection in other countries, handles most of the foreign correspondence, and also that with the Department of State in Washington. This relieves the Directing Committee of the many details connected with travel, border regulations, temporary residence in the United States, health insurance, *et cetera*.

The purposes of the plan, previously outlined in a simple brochure of information on The Inter-American Orthopaedic Fellowship Program, are as follows:

1. To increase inter-American understanding and to stimulate cultural exchange among the American Republics.

2. To stimulate progress in orthopaedic surgery in the Western Hemisphere, and to serve as a medium for the exchange of knowledge and acquaintanceships in this field among the American Republics.

3. To provide better preparation for orthopaedic surgeons in the American Republics.

Up to the present time, fifteen Latin-American students have come to the United States to take advantage of the fellowships. One student has finished a well-rounded period of orthopaedic training and returned to his home in Brazil. The Republics now represented in this country by fellowship men include the following: Mexico, Brazil, Argentina, Peru, Ecuador, Uruguay, Paraguay, Haiti, Nicaragua, Costa Rica, and Chile. Periodic reports received from these students indicate that they are highly pleased with their opportunities and experiences to date.

Many training centers in the United States have evidenced a willingness to participate in this program. Foreign fellowship men are now, or have been, in training at the following centers: Hospital for Special Surgery, New York City; Children's Hospital, Boston; Lahey Clinic, Boston; Johns Hopkins University, Baltimore; University of Pennsylvania, Philadelphia; Hospital for Joint Diseases, New York City; University of Chicago, Chicago; University of Wisconsin, Madison; University of Iowa, Iowa City; Tulane University, New Orleans; University of Cincinnati, Cincinnati; Willis C. Campbell Clinic, Memphis; Children's Hospital School, Los Angeles; Shriners' Hospital for Crippled Children, Greenville, South Carolina; Charlotte Memorial Hospital, Charlotte, North Carolina; and North Carolina Orthopaedic Hospital, Gastonia.

The first group of students placed in training under this plan came to us on short notice, but it is anticipated that the future policy will be to have a candidate selected, if possible, a year in advance of placement, and the center of training determined before the student leaves home. This program may also be affected by the demand on teaching centers for the further education of men, soon to be released from military service, who desire special orthopaedic training.

The Committee on Inter-American Fellowships in Orthopaedic Surgery, in conjunction with the W. K. Kellogg Foundation and cooperating agencies, desires to function as best it can under existing conditions in meeting some of the demands now being made for fellowships in this country—demands which will undoubtedly be greatly increased in the future—for special educational opportunities in the United States.

The Committee on Inter-American Fellowships is composed of: Dr. George E. Bennett, Dr. Guy W. Leadbetter, Dr. Samuel Kleinberg, Dr. Guy A. Caldwell, and Dr. O. L. Miller, Chairman.

THE BRITISH ORTHOPAEDIC ASSOCIATION

The Spring Meeting of The British Orthopaedic Association was held at Horton Hospital, Epsom, and at Hill End Hospital, St. Albans, on June 1 and 2, respectively, under the presidency of Mr. St. J. D. Buxton. A valuable part of the meeting was devoted to a consideration of the subjects: "Bone and Soft-Tissue Deficiency in the Limbs", "Penicillin", and "Vascular Lesions".

Wing-Commander I. Lawson Dick, Royal Air Force, in "Preliminary Observations on the Use of Cancellous-Bone Transplants", gave an admirable historical survey of the knowledge of osteogenesis in relation to bone-grafting since the time of John Belchier in 1736. He said that the generally accepted view now is that the viability and osteogenetic properties of transplanted bone depend upon the facility with which it can be revascularized. Osteogenesis and viability were long delayed in the depths of massive cortical grafts and most readily ensured in cancellous bone. If the mechanical stability of cortical grafts can be maintained by other means, healing and consolidation will be hastened by the superior osteogenetic properties of cancellous bone. A disadvantage of removing grafts from the tibia

is the not uncommon occurrence of fatigue fractures in the donor bone. The most rapid and surest method of bone transplantation has been with the use of cancellous chips from the ilium.

Mr. S. L. Higgs dealt with "The Use of Cancellous Chips in Bone-Graft Surgery", as a result of his observation of the work of Mowlem in plastic reconstruction of the jaw. He gave a review of seventy-one cases of bone-grafting, sixty for non-union of the long bones. In twenty, cortical grafts alone were used; in forty, cortical bone plus cancellous bone chips were used. All had resulted in bony union, but with cortical grafts alone union had taken at least twice as long as where both types of graft were employed. An exception was the femur, where the average time for healing with cortical grafts alone had been 50 per cent. longer. In the operative procedure it was essential, if cancellous chips were to do their work well and quickly, that rigid fixation be applied. To maintain this, with length and alignment, was the reason for combining a cortical graft with the chips. The methods used for various long bones were described, and the speaker emphasized that there need be no hesitation in excising all sclerosed bone from the site of non-union; similarly, all fibrous tissue could be removed to facilitate vascularization. Any associated skin defects must first be adequately treated by plastic methods.

Mr. Ivor Robertson described the "Treatment of Chronic Infective Osteitis", the essentials of which include a careful but extensive excision of all infected bone and scar tissue and the replacement of tissue loss by bone, muscle flaps, and full-thickness skin grafts. Obviously, such treatment requires careful selection, and the cases described had been of chronic hematogenous osteitis, limited in area and surgically accessible, and cases of chronic osteitis resulting from compound fractures or from war wounds. The treatment was carried out in three stages, with controlled penicillin therapy, and comprised the following procedures: first, excision of the bone and soft-tissue defects and then covering with Thiersch's graft; second, a month later, closure, after this graft had been removed and a full-thickness skin graft substituted; third, at least two months later, bone-grafting. Where an ununited fracture is present, this involves both cortical and cancellous chips. In cases of chronic hematogenous osteitis, the second and third stages may be combined, and iliac cancellous chips alone are packed into the dead space between the walls of the cavity and skin flap. To ensure an adequate blood supply, a muscle flap is swung over them and sutured to the periosteum.

Mr. Rainsford Mowlem discussed "The Problem of Soft-Tissue Defects in the Limbs". He emphasized the need for continuous care of all elements of damage (skeletal, vascular, neuromuscular, and to the skin covering) in all injuries. No element should be ignored, but from every point of view a limb, otherwise intact, is useless without its skin covering. Indeed, fibrosis secondary to infection and exposure will exert an influence upon underlying muscles and joints, which will prevent adequate treatment for these deeper parts and greatly increase the disorganization of the limb as a whole. The use of free grafts and pedicles, or flaps, was discussed. In the former, split grafts can be applied at any time when there is a good vascular surface, usually as soon as possible. For adhesion, maintained pressure is preferable to glue. If the bed is avascular, it must be excised. Infection is not a contra-indication to grafting, so long as it is controlled by suitable chemotherapy. *Bacillus pyocyaneus*, *Proteus*, or *Bacillus coli* infection presents a special problem, but even here successful grafting is not impossible. Exudation is a difficulty, but its mechanical effects can be minimized by using strip grafts or postage-stamp-shaped grafts. After a month, all grafts tend to become dry and to contract; massage with grease will help. Below-the-knee grafted areas require prolonged pressure bandaging to reduce the ill effects of oedema. In weight-bearing surfaces, keratosis may be aided by the use of the sulfhydryl radical. Usually, however, split grafts should be only a preliminary to whole-thickness grafts. The splintage necessary to prevent contracture in grafts on flexor surfaces was discussed. The design, formation, and methods of transplanting whole-thickness grafts were discussed, particularly the possibilities of flap grafts in the primary treatment of certain types of injury, noticeably in the hand. The sites most suitable for particular flap and tube grafts elsewhere, and in secondary treatment, were also discussed.

"The Future of Penicillin Treatment" was discussed by Professor L. P. Garrod, who at the outset contrasted penicillin therapy for bone and soft-tissue lesions; results in the latter can almost be guaranteed, but the story is very different in the former. In the future, more liberal and purer supplies of penicillin should be available. With greater purification, three types of drug are being isolated, the use of which may be specialized according to the type of infection. Improved methods of parenteral administration now give greater comfort to the patient and greater convenience to the surgeon. One of the difficulties of the drug is the rapid dissipation of its effect, and this problem is being investigated by United States workers with the development of suspensions in oil, which are more slowly absorbed. British economy has necessitated the local administration of penicillin, and there is much to be said for the good effects when thus used. Adequate concentration can be achieved where most needed. Economy in the use of the drug hitherto has resulted in the discovery that the effect of penicillin does not depend on its concentration. The full action of the drug is obtained in low strengths; one gains nothing by increasing it, and, in fact, sometimes the reverse effect is produced. The use of penicillin combined with sulfonamides is still under discussion. Professor Garrod's own work, though not conclusive, suggests that the sulfonamides interfere with the effect of penicillin on rapidly multiplying organisms.

Dr. G. F. Kalmykov, Union of Soviet Socialist Republics, discussed the question of "End-Bearing

Amputation Stumps in the Lower Extremity". In the reconstructive surgery of the postwar era, an important field will concern itself with re-amputation, since the practice of emergency primary amputation behind the battlefield leaves definitive amputation to a later date. The extent of this policy varies in different nations. In Soviet Russia, not less than 80 per cent. of re-amputations are required. At one large center in the United States, the speaker found 78 per cent. of re-amputations required. In British hospitals not more than 25 per cent. are required, which is explained by the more frequent flap amputation instead of the guillotine type. Wherever possible, Soviet surgeons seek to create an end-bearing stump by means of an osteoplastic operation. Thus they follow the work of Pirogoff, whose well-known operation in the lower leg is being done in Russia today. Other methods practised are those of Bier in below-the-knee amputations, and the Gritti-Stokes' operation for above the knee. After such operations, it is very important to prepare the stump properly for end bearing. By end bearing, better distribution of weight within the prosthesis is achieved, with consequent improvement in gait and in confidence. Dr. Kalmykov, realizing British conservatism in this matter of end-bearing stumps, made a plea for further work in this sphere.

Dr. M. N. Polonsky, Union of Soviet Socialist Republics, gave a detailed description of a "New Type of Prosthesis in Amputations Through or Near the Hip-Joint", which he thought solved the well-known difficulties of limb-fitting in this region. The advantages claimed were the relative lightness, greater comfort in walking and sitting, and greater economy in manufacturing costs and time. A normal type of above-the-knee prosthesis was employed, fixed to the usual type of pelvic band, from the front of which a broad leather sling passed continuously downward into the front of the prosthesis, over a transversely-placed wooden roller, and out through the back of the limb. It was then attached to the back of the pelvic band, where its tension could be adjusted by lacing. The top of the appliance held a slightly hollowed, springy platform with soft felt lining, upon which the soft parts of the hip gained a shock-absorbing support in walking.

Dr. E. J. Crisp read a paper on the subject of intervertebral-disc lesions, with special reference to early diagnosis and treatment. The lumbar discs suffer trauma more frequently than is generally appreciated, but, in the absence of crural pain or roentgenographic changes, the resulting lesion is frequently mistaken for sacro-iliac strain or fibrositis. The condition may be easily recognized by the extreme and persistent lumbar spasm at first associated with an increase in the lumbar concavity; later, scoliosis to the side of the lesion and lumbar kyphosis develop with sciatic pain. The lordosis occurs when rupture of the annulus fibrosus is incomplete, and the kyphosis when it has completely ruptured. Conservative treatment was advised along such well-recognized lines as the use of the plaster jacket. The essence of Dr. Crisp's views was that persistent lumbar spasm and a "tight" lumbar spine, in an otherwise healthy patient, indicates trauma to a disc and should be dealt with before the onset of sciatica.

Mr. J. E. O'Connell dealt with the "Diagnosis of Lumbar Intervertebral-Disc Protrusions", based upon a postoperative study of 240 patients. Of these explorations, 227 had given positive evidence of intraspinal protrusions. By careful analysis of the clinical picture, it was possible to localize accurately the site of stretching of the intraspinal nerve root, which affected the extradural portion of the nerve root leaving the spinal canal at the intervertebral foramen next below the disc affected. In his series, thirty-nine cases had been studied before operation by myelography, with six negative explorations (15 per cent.). In 201 cases explored without myelography, there had been only seven negative operations (3.5 per cent.). While a variety of conditions can occasionally produce a picture similar to that of a lumbar-disc protrusion, there are only three which do so at all frequently. These are an intraspinal tumor, a metastatic tumor in the lumbar vertebrae, and spondylolisthesis. Clinical examination will help in the differentiation, but certain accessory methods may be necessary. Concerning operative treatment, the speaker emphasized the need for adequate excision of the disc. With proper selection, the results in the majority of cases are excellent. Backache may be frequent, but is rarely incapacitating. There have been a few recurrences, most frequently in the opposite leg.

Professor J. Paterson Ross read a paper, dealing with a series of examples of "Ischaemic Phenomena Following Vascular Injuries" in the lower extremity. He drew attention to the relation of the origin of the sural arteries, supplying the gastrocnemius muscles, to a region of special vulnerability in the popliteal artery. If these and all the terminal branches of that artery were blocked, the leg would probably be useless and sympathectomy would not improve it; pain might necessitate amputation. Where the sural arteries had been blocked, but the collateral circulation preserved, pain in the *upper* calf was troublesome after walking 300 yards. This was relieved by sympathectomy. If the popliteal artery had been damaged below the sural vessels, pain was found only in the *lower* calf and was not appreciably affected by sympathectomy. Block high up in the popliteal artery or femoral artery gives a good leg which can often be improved by sympathectomy, because the vessels to the calf, even if small, are still open. The popliteal artery is vulnerable to direct injury from bone and is liable to "spontaneous" thrombosis, which may be related to less direct trauma and to thrombosis resulting from degenerative changes. In none of the cases described did gangrene occur; but in cases in which the popliteal vein or femoral vein had to be tied, venous congestion was troublesome, and became worse after sympathectomy. In an arteriovenous

fistula, if the main artery was ligated, a good collateral arterial circulation developed *but*, without coincident ligation of the vein, excessive venous drainage rendered the circulation of the periphery precarious. In one case of external iliac-artery ligation in which the arteriovenous fistula had not been recognized, and also in two cases of wounds of the femoral artery and in two wounds of the popliteal artery, immediate paralysis of the common peroneal nerve occurred, suggesting an important additional segmental supply from the popliteal artery.

Major D. Lloyd Griffiths, Royal Army Medical Corps, remarked on the large number of cases of vascular injury to the larger vessels, which he had seen in two years at a variety of centers. He attributed this to the effect of chemotherapy in saving a great many limbs which formerly would have been amputated. In the past, and even now, the ligature of main arteries had been carried out too lightheartedly. His opinion was that a very large proportion, even at reputedly safe sites, had been followed by vicious effects in the periphery,—such as intermittent claudication, incorrigible anaesthesia, and gangrene of the digits. He pleaded for the greater practice of lateral suture of arterial wounds and the avoidance of ligature.

Mr. James Patrick discussed the diagnosis and treatment of seventeen cases of "Fracture of the Medial Epicondyle Displaced into the Elbow Joint". Roentgenographic diagnosis may appear difficult, because the patient is unable to extend the elbow in order to afford a good anteroposterior view. If the medial epicondyle can be seen in the lateral view through the joint line, it can be regarded on this view alone as being incarcerated in the joint. After reduction of the incarcerated fragment, and in all simple fractures of the medial epicondyle, the fragment lies above the level of the joint line and so ceases to be visible in the lateral view. In early cases, reduction can be done easily by anaesthetizing the patient, gently abducting the forearm on the humerus, and applying faradism to the flexor muscles. Fractures not detected for five or six weeks after injury should be treated conservatively. In such cases, the epicondyle eventually develops a bony fusion to the ulna. Anterior transposition of the ulnar nerve is probably unnecessary.

Mr. C. Price Thomas discussed "Scoliosis in Relation to Thoracic Disease". This type of scoliosis follows most commonly upon conditions involving the pleura,—such as chronic empyema and imperfectly treated hemothorax. Pulmonary fibrosis and atelectasis also give rise to the deformity, but do so only when the mediastinum is fixed. The underlying cause is either a concentric pull on the chest wall toward the lung root, or an abnormal intrathoracic negative pressure, or both. There is a striking difference in the chest deformity from that found in primary scoliosis; the intercostal spaces are much more contracted, the curvature of the rib angles is increased, and the anterior part of the chest is flattened on the *concave* side of the scoliosis, the reverse, of course, to that found in primary scoliosis. The impression was also gained that vertebral rotation is less marked in thoracic scoliosis. Mr. Thomas illustrated the types of remedial exercises used, not only in the prevention of the deformity, but also in the course of treating the causal disease and in the after-care of thoracic operations. In some instances, a certain degree of scoliosis was inevitable, because the muscles had lost the rib attachments upon which so much spinal stability depends, but even this condition could be mitigated by remedial exercises.

Mr. A. D. le Vay, in a paper upon "Costoclavicular Compression of the Brachial Plexus", discussed the importance of this factor in the explanation of certain neurological and vascular disturbances in the upper extremity. The conclusions were based upon one case and the recent literature. The patient under discussion had, a year previously, been treated for symptoms of the "scalenus syndrome" (without cervical rib) by the scalenus anterior tenotomy, with consequent aggravation of symptoms. The patient was then operated upon by Mr. le Vay under local anaesthesia, and it was found that the subclavian artery and brachial plexus were very superficial and were bound to the back of the clavicle by dense inflammatory fibrous tissue. The artery was small and transversely grooved, as if just released from a clamp. When the shoulders were braced back, these structures were firmly squeezed between the clavicle and rib; a portion of the latter was excised so that artery and plexus sank back against the pleura. This operation was quickly followed by almost complete recovery.

Dr. Phillippe Bauwens demonstrated a piece of apparatus, devised to make quantitative estimations of action potentials on volition of muscles. The equipment basically consisted of a conventional high-gain amplifier, such as is commonly used for electromyographic explorations, feeding into a loud speaker and a cathode-ray oscillograph. It was modified so that a resistance could be substituted for the coil of the loud speaker, which would act as a non-inductive load of known value.

A system of copper-copper oxide rectifiers, with a choke-capacity reservoir and a microammeter in series with a high resistance, could be shunted across selected portions of this load resistance. The readings on the microammeter bore a relation to the electrical disturbances around the needle electrode inserted into the muscle under examination.

With the controls set in the usual position, the readings obtained for a normal muscle, fully exerting itself against complete opposition, were around 350 microamperes, and were surprisingly constant.

In his introductory remarks, Dr. Bauwens paid tribute to those who had investigated the qualitative aspect of electromyography in peripheral-nerve lesions, and stressed the importance of recognizing the various types of electrical phenomena which characterized normal and abnormal activity in muscle.

In order to assess progress, or the lack of it, it was of advantage to be able to make quantitative estimations of action potentials, and he was satisfied that the measurements obtained by this apparatus were of significance, provided the pitfalls were recognized. In this connection, he pointed out that measurements were related solely to the disturbances immediately around the point of the needle electrode, and that, consequently, one might obtain different readings in different parts of the same muscle. Again, one was dependent on the cooperation of the patient and his ability to direct his efforts into the proper channels. Some of the potentials, registered in muscles with a regenerating motor nerve, were very high and polyphasic. Consequently, they gave rise to unduly high readings, which might prove misleading. It was equally important to ensure that the maximum effort was always being made. The possibility of numerically counting the action potentials by means of an integrating device was under consideration.

Dr. Bauwens thought that electromyographic exploration and the testing of muscles and nerves by means of electrical stimuli were complementary. He demonstrated a valve-operated machine which generated impulses of rectangular wave-form of 1/1000 second, 1/100 second, and 1 second duration. The values of the currents required for a minimal response, using these three impulses, gave an abbreviated intensity-duration curve which was of greater diagnostic value than the indications obtained by the classical method, using interrupted galvanic current and faradic current which defied measurement.

Mr. W. Sayle Creer demonstrated a cinematograph dealing with "Some Foot Faults Related to Form and Function" which, by means of dissections and ingeniously contrived models, illustrated the anatomy and physiology of the foot, its pathology and treatment.

A clinical demonstration was given at Horton Emergency Medical Service Hospital by Mr. St. J. D. Buxton and by members of the staff of that Hospital; by Dr. P. H. Jayes of the Plastic Unit, East Grinstead; Dr. E. E. Harris of the Heritage Craft Schools; Mr. B. H. Burns and Mr. R. H. Young of Bottleys Park; Mr. F. C. Durbin, St. Nicholas Hospital, Pyrford, and Mr. G. N. Goulden, Guildford.

At this meeting the following Associate Members were elected to **The British Orthopaedic Association:**

Capt. Moss Albert, 31 Oakdene Park, Finchley, London, N.3
Mr. K. A. Butler, Lord Mayor Treloar Hospital, Alton, Hampshire
Major G. R. Clarke, 47A High Street, West Bromwich, Staffordshire
Mr. A. J. Craig, 138 Tower Road, Sliema, Malta
Surg. Lt. V. M. Franklin, c/o National Provincial Bank, Ltd., Stratford-on-Avon
Squad. Ldr. K. E. Guest, 38 Davison Avenue, Whitley Bay, Northumberland
Squad. Ldr. J. R. Hughes, Glenwood, Llangollen, North Wales
Mr. E. S. Jamieson, White Lodge Hospital, Newmarket
Lt. Col. W. A. Law, 100th British General Hospital, Central Mediterranean Force
Squad. Ldr. N. Livingstone, Royal Air Force Rehabilitation Unit, Loughborough, Leicestershire
Mr. M. McLearie, 12 Caddle Hill Street, Greenock, Scotland
Squad. Ldr. E. F. Mason, Royal Air Force Rehabilitation Unit, Loughborough, Leicestershire
Major J. M. Quinlan, 53 Queen's Road, Southport, Lancashire
Lt. Edmund Shephard, Ellescombe, Butlers Cross, Aylesbury, Buckinghamshire
Mr. S. A. Sinclair, Beverley Emergency Hospital, Beverley, East Yorkshire
Flt. Lt. E. W. M. Williams, 10 Cardiff Road, Boston Manor, London, W.7

SIR HENRY GAUVAIN

In the April issue of *The Journal* appeared the obituary of Sir Henry Gauvain. In one of the closing paragraphs the author refers to Sir Henry's capacity to inspire happiness and contentment among his patients. Concerning this characteristic of Sir Henry, a reader writes:

"At the time of the German invasion of Belgium in May 1940, the Delcroix Hospital at Ostende had under its care 100 crippled children; plans were hurriedly made for their evacuation by sea to one of the French ports. Before they reached their destination, these ports were in enemy hands and the captain decided to head for England. Aboard this vessel were sixteen Belgian nuns, who cared for these destitute children. When the ship reached Falmouth, it presented the harassed British Government with an additional problem. It was to Sir Henry that the Government appealed. Without any hesitation, he placed the private pavilion of Morland Hall at the disposal of these youngsters; most of them were suffering from surgical tuberculosis, others were victims of infantile paralysis.

"In December 1941, I was in England as Administrator of the American Hospital in Britain and the Chief Surgeon of our Hospital, Dr. Charles H. Bradford of Boston, invited me to accompany him on a visit to Sir Henry. I shall never forget the smiles on the children's faces and the remarks uttered in their native dialect when Sir Henry entered their rooms. He was indeed a great man."

Current Literature

BONE-GRAFTING IN THE TREATMENT OF FRACTURES. J. R. Armstrong, M.D., M.Ch., F.R.C.S. Foreword by R. Watson-Jones, B.Sc., M.Ch.Orth., F.R.C.S. Baltimore, The Williams and Wilkins Company, 1945. $7.00.

This 175-page monograph, as its title implies, is not confined to the treatment of ununited fractures, but also includes the use of bone grafts in selected fresh fractures. The author gives a concise, accurate, and detailed description of bone-grafting as used in his Royal Air Force Service, which should be of great value to those not thoroughly familiar with the many technical details associated with successful bone transplantation. The book is well written and is profusely illustrated with black-and-white and color plates; the former are excellent, and the latter are adequate to convey the desired information.

Separate chapters are devoted to bone-grafting of each of the major long bones and of the spine; additional chapters deal with bone-grafting of special fractures, such as fractures of the neck of the femur, of the carpal scaphoid, metacarpals, and malleoli, and with fusion of the subastragalar and tarsal joints. In general, the author prefers the onlay type of bone graft. He recommends the use of bone grafts in certain fresh fractures as an elective procedure; although this is not generally accepted at the present time, a group has been using this method in recent years.

A detailed description is given of an original technique for grafting of the carpal scaphoid. The author condemns metallic fixation of malleolar fractures, because of the alleged injurious effect on the adjacent joint; he feels that bone pegs should be used. In fractures of the tarsus requiring fusion of one or more of the tarsal joints, he recommends a "buried" graft; this technique is clearly described, with special reference to operative fusion of the subastragalar joint.

In the Appendix, several statistical tables are presented; data are correlated from 1161 fractures, in 76 (6.5 per cent.) of which bone-grafting was used.

This is a concise monograph which should be useful to the orthopaedic surgeon.

INTRODUCCION AL ESTUDIO DE LOS INJERTOS OSEOS (Introduction to the Study of Bone Grafts). Nicolás N. Perruelo. Buenos Aires, El Ateneo, 1945.

This well-organized monograph seems to have been written with the particular needs of the busy orthopaedic surgeon in mind, and it is to be regretted that an English translation is not in existence. Most of the work described by Dr. Perruelo has been carried on at the Hospital Teodoro Alvarez in Buenos Aires, Argentina, of the staff of which he has been a member for many years.

The first section deals with normal bones. The second part of the work discusses in great detail the entire subject of bone-grafting, from its early beginnings to the methods now being employed. The latter part of the book is given over to the clinical histories of some ninety patients, and many excellent roentgenograms are included. The illustrations throughout the text are of the highest order, and do much to emphasize the good results obtained by Dr. Perruelo.

CLINICAL TRAUMATIC SURGERY. John J. Moorhead, B.S., M.D., D.Sc., F.A.C.S., (D.S.M.). Philadelphia and London, W. B. Saunders Company, 1945. $10.00.

Moorhead's justification for compiling a textbook of general knowledge and experience upon a subject which deals with most, if not all, the specialties is summed up in the statement that trauma "brings surgery to the crossroads".

The book deals with subjects as diverse as war injuries, industrial injuries, and traumatic neuroses; as technical as fractures of the bones of the face and the relation of trauma to appendicitis, abortion, and visceral displacement; as commonplace as backache; and as controversial as medicolegal phases of trauma. The bulk of the work is devoted to discussions of fractures and wounds with their complications; but separate chapters deal with amputations, injuries of nerves and blood vessels, and deformities of the hands and feet. The author constantly emphasizes what he considers to be the simple and fundamental principles, as well as the practical and available measures, which apply to the conditions studied. He outlines important alternative methods of treatment whenever they are currently accepted, without hesitating to express his own preference.

This is distinctly not a book for specialists; yet it contains features which even the specialist will enjoy reading. The author has contributed greatly to the art of teaching his subject, because he has clarified and simplified the task of understanding it. The specialist may be humbled a little in reading this volume by realizing how small a part of the total problem of traumatology his single department can deal with. The presentation of the subject as a whole will help him to switch from an oil-immersion view of his technical field to the lower-powered lenses of common practice. The only danger from

such a book is that it might induce surgeons less experienced than the author to assume the role of experts in traumatic surgery, without acquiring the necessary breadth of experience or specialized training for such a practice. The very content of the book shows that traumatic surgery can never be a single specialty; but is rather a field which draws from many specialties.

FISIOPATOLOGIA DEL METABOLISMO OSEO (Pathological Physiology of Osseous Metabolism). Carlos F. de Arazoza. La Habana, Cultural, S. A., 1945. (Biblioteca del medico practico, Volumen XXIII).

De Arazoza has summarized our present-day knowledge of osseous metabolism. He has set for himself three aims: a study of the related metabolism of bony tissue, a review of the factors which intervene in the metabolism of bone, and a study of the diseases in which changes in osseous metabolism take place. While there is little new in the book, it is a careful résumé and digest of data on the chemical changes which take place in bone. Theories of calcification are reviewed. The author adheres to the ferment theory. Phosphatase seems to be essential for the laying down of lime. The roles of calcium, phosphorus, and magnesium are discussed in detail. These salts move rapidly between the blood serum and osseous tissue, as shown by radio-active phosphorus.

The parts played by vitamin A, the parathyroid gland, phosphatase, vitamin D, and vitamin C are described; tables of their physiological action are appended to each chapter. Paget's disease, von Recklinghausen's disease, rickets, scurvy, coeliac disease, osteomalacia, osteopsathyrosis, lipoid diseases of bone, and marble-bone disease are discussed in relation to osseous metabolism.

This little book is a valuable reference for students of diseases of bone. It is well written, and the illustrations are good.

FACIAL PROSTHESIS. Arthur H. Bulbulian, M.S., D.D.S., F.A.C.D. Philadelphia and London, W. B. Saunders Company, 1945. $5.00.

Prosthetic restoration of missing parts of the extremities has long been an accepted orthopaedic procedure, but surgeons know very little about the possibility of prosthetic restoration of deformities of the face and jaws. One reason is that this specialty has been developed by dentists, and reports on such work appear almost exclusively in dental periodicals and books. Moreover it is a highly specialized subject, and consequently very few members of the dental profession have taken the training necessary to enable them to contribute to the solution of facial and maxillary problems.

Prosthetic methods of reconstruction have received a good deal of attention since World War I. Knowledge gained at that time was used successfully by surgeons in the repair of deformities resulting from malignant diseases of the face and jaws.

This concise book on facial prosthesis undoubtedly will fill a great demand, because at the present time there is more interest in the subject than ever before. The scope of the book, however, is limited to a discussion of artificial restoration of the face, especially the ear, nose, and orbit. It does not cover reconstructive measures for maxillary defects, which are often part of such deformities.

As the author plainly states, the repair of facial deformities is primarily a surgical problem, but there are numerous conditions and circumstances which make surgery impossible or inadvisable. In such cases, artificial restoration, temporary or permanent in nature, of the missing parts of the face becomes desirable. The author has somewhat overemphasized the use of latex as a suitable material for restoration, this reviewer believes, and has not given enough importance to other materials, such as acrylics.

The book is divided into fourteen chapters, and the classification of subjects is excellent. There are numerous diagrams and illustrations to help the reader in understanding the techniques of restoration. It is a good, small book to introduce prosthetic concepts and techniques to those interested in restorative problems of the face.

ÜBER OSTEOMYELOSKLEROSE (OSTEOMYELOSCLEROSIS). G. A. Landoff. *Acta Radiologica*, XXV, 81, 1944.

Apart from Albers-Schönberg's disease, the clinical entity of the various forms of osteosclerotic anaemia are but little known. Most commonly they are recognized only at autopsy, because of the absence of any characteristic clinical picture.

In the author's case and the sixteen which he reviews from the literature, the disease occurred primarily in adults beyond the age of fifty. The blood picture is not typical, but is in general that of a progressive anaemia. The white cells show all variations from that of complete aleukaemia to that of myeloid leukaemia. The sedimentation rate is increased.

Opinions vary as to the nature of the disease in the bone. Some consider that atrophy of the marrow is associated with extra-osseous blood formation. Others consider that the picture is dominated by fibrosis of a leukaemic marrow.

The bone changes affect only the spongiosa; Wolff called it an "endosteal hyperostosis with metaplastic bone formation". Microscopically it is found that the bone trabeculae are less numerous. There is evidence of new-bone formation, but the osteoblasts and osteoclasts are strangely absent. The marrow cavities are fibrotic with occasional clumps of myeloid and erythropoietic cells.

Roentgenographically the disease is characterized by the appearance of broader, well-defined spongiosa trabeculae, with narrowing of the marrow cavity. This is best seen in the vertebral column and the pelvis. In the opinion of the author the condition is to be considered as the earlier phase of the disease known as "marble bone".

It may be differentiated from metastatic carcinoma by the more widespread osseous involvement. It may be differentiated from chronic fluorine poisoning by the absence of spotty cortical thickenings, calcification of the ligaments, and osteophyte formation. No therapy is effective.—*Henry Milch, M.D., New York, N. Y.*

De la forme kystique des métastases cancéreuses des os (Cystic Form of Metastatic Carcinoma of Bone). Bengt Engfeldt. *Acta Radiologica,* XXV, 317, 1944.

The cystic form of osseous metastases from carcinoma is apparently very rare. In the literature are reported one case derived from a carcinoma of the prostate, one from carcinoma of the oesophagus, and two from carcinoma of the breast. The author adds a case in which the primary site was the lung.

The widespread osseous metastases caused absolutely no symptoms, and were discovered in the course of autopsy. The cysts were lined with cancer tissue, and were well demarcated from the surrounding tissue. The author reviews the theories which had been advanced to explain the formation of cysts in metastatic carcinoma.—*Henry Milch, M.D., New York, N. Y.*

Über einen mit Röntgenstrahlen Behandelten Polymyositisfall (Case of Polymyositis Treated by Roentgenotherapy). Hugo Ahlbom. *Acta Radiologica,* XXV, 403, 1944.

Polymyositis or dermatomyositis is a rare disease first described in 1890. It presents the appearance of an acute infection with intermittent course. Inflammation of the back and extremity muscles is most common. The etiology is unknown and the prognosis is bad.

The author recommends the use of small doses of roentgenotherapy. If these are unsuccessful, he advises the use of large doses. A case is reported in which this type of treatment appeared to have given good results.—*Henry Milch, M.D., New York, N. Y.*

Roentgen Treatment and the Course of Cure of Giant Cell Tumor in the Osseous System. Gösta Jansson. *Acta Radiologica,* XXV, 569, 1944.

Roentgenographically the local fibrocystic diseases may be divided into three types: "(1) the bone cysts occurring in young persons under the age of fifteen, and involving the metaphyses; (2-a) the benign slow-growing cell tumors occurring in patients between the ages of twenty and forty, and involving the epiphyses; and (2-b) the strongly progressive epiphyseal type of giant cell tumors, in which the osteolysis develops quickly, and which appear locally malignant".

It is the opinion of the author that roentgenotherapy is the method of choice in the treatment of this condition. He cautions against the combination of surgery and roentgenotherapy. He notes that excessive radiation is often harmful, and may lead to initial osteolysis of the involved bone.—*Henry Milch, M.D., New York, N. Y.*

Fall von Chondrodystrophia congenita calcificans (A Case of Chondrodystrophia Congenita Calcificans). Sigvar Jorup. *Acta Radiologica,* XXV, 580, 1944.

This disease was first described by Conradi in 1914. It appears to belong to the general category of the foetal chondrodystrophias, but is very rare. The disease occurs in the newborn, and is characterized by the appearance of small localized calcium deposits in the epiphyses of chondrogenous bones. In one case in which pathological material could be studied, small areas of chondromalacia with calcium depositions were found. As a consequence, a moderate micromelia, affecting primarily the lower extremities, has been observed.

The prognosis in these cases is apparently determined by other malformations which are associated with it. As regards the growth of the bones, the prognosis appears not unfavorable, and in this respect a marked difference between this disease and the classical type of chondrodystrophy is to be noted.

The patient here reported was first seen at the age of twelve days, and has been followed for a period of fourteen months. A number of interesting roentgenograms illustrate the article. A review of previously reported cases is given.—*Henry Milch, M.D., New York, N. Y.*

The Instability Associated with Disk Degeneration in the Lumbar Spine. Folke Knutsson. *Acta Radiologica,* XXV, 593, 1944.

"Examination of anatomic specimen of the lumbar spine has shown that disk degeneration (osteochondrosis) causes abnormal movements between the vertebrae (Hildebrandt, Guntz) and it has been assumed that clinical symptoms of disk degeneration are due to this instability. Putti aptly likened the condition to pseudo-arthrosis."

The author notes that the ordinary roentgenographic examination, made with the patient recum-

bent, is intended for the study of anatomical conditions. In order to establish functional capacity, he recommends making roentgenograms "with the patient standing and bending as far forward and backward as possible". With these complementary pictures, the roentgenographic diagnosis of disc degeneration may be made on the following findings:

1. Narrowing of the intervertebral space;
2. Reactive changes, such as sclerosis of the vertebral surfaces and lipping of the margins;
3. Vacuum phenomena, visualized as fissure spaces in the discs on backward bending;
4. Abnormal position of the vertebrae in relation to each other;
5. Abnormal motion of the vertebrae.

The exposures are made in the following manner:

1. Standing at the edge of the table, the patient extends the spine maximally while a lateral view is made.

2. Sitting on the edge of the table, the patient flexes the spine maximally while a lateral view is made.

Roentgenograms were made at a distance of one meter.

Normally, flexion or extension of the spine leads to unilateral compression of the disc on the concave side. When the disc is injured, this shock-absorbing function is impaired, and in its place the vertebra is displaced in the direction of motion. The fifth lumbar vertebra is apparently an exception to this rule. While retroposition occurs in extension, it is accentuated in flexion also. The author attributes this to other factors which he does not discuss.

By these methods the author believes he can diagnose disc instability before anatomical signs appear.—*Henry Milch, M.D., New York, N. Y.*

A Contribution to the Treatment of Fractures of the Posterior Border of the Tibia by Malleolar Fractures. Gunnar Nyström. *Acta Radiologica,* XXV, 672, 1944.

The statistics of Hendelberg have conclusively demonstrated the unfavorable prognosis of fracture of the posterior lip of the tibia (third malleolus). In those cases in which this fragment includes one third or more of the articular surface, a displacement of more than two millimeters, a bad result with invalidism may be expected.

The author reports his percutaneous method of fixing such a fragment. The fracture is reduced, and a plaster-of-Paris boot is applied. A window is then cut over the heel and the Achilles tendon. Under the fluoroscope, a common carpenter's awl is introduced, and the posterior fragment is levered into position. The awl is removed, and the fragment is fixed by a Kirschner wire which is cut off and incorporated into the plaster. The wire is removed after about one month, and weight-bearing is gradually begun. The plaster is removed six weeks after operation.—*Henry Milch, M.D., New York, N. Y.*

Arthrography of the Mandibular Joint. Flemming Nørgaard. *Acta Radiologica,* XXV, 679, 1944.

Roentgenography of this joint presents many difficulties. In an effort to overcome some of these, particularly in cases where non-osseous lesions exist, the author has employed perabrodil or uroselectan in thirty-four cases.

With the patient supine, head turned to one side, mouth open, the skin midway between the tragus and the condyle of the mandible is anaesthetized with novocaine. The needle is then pushed into the lower part of the mandibular joint. About one cubic centimeter of a 35 per cent. perabrodil solution is then injected, and an exposure is made. Thereafter the upper part of the joint is injected with from 1.5 to 2 cubic centimeters of the same contrast substance.

The patient experiences a sensation of painful tension and inability to shut the mouth in a normal manner; this sensation usually disappears quickly, sometimes within a day. Only one joint is examined at a time. The second joint may be examined after an interval of several days, preferably a week. A more complete report of the work will be published after more data have been accumulated.—*Henry Milch, M.D., New York, N. Y.*

Teste colorimetrico para avaliacão da capacidade circulatoria e da vitalidade de uma regiao (Colorimetric Test for Evaluation of the Circulatory Capacity and the Vitality of a Given Region). Mario Ottobrini Costa. *Anais Paulistas de Medicina e Cirugia,* XLVIII, 193, 1944.

In the matter of amputations consequent upon arterial obstructions, the question as to economically delayed amputation or immediate amputation has always been difficult to solve. Many different tests, oscillometric, colorimetric, thermometric, have been devised, but none gives any positive evidence as to the extent or the importance of the collateral circulation.

In an attempt to establish clinical rules to guide amputations, Quénu recommended: (1) amputation of the toe for gangrene of the phalanx, (2) amputation of the foot for gangrene of the toe, and (3) amputation of the lower third of the leg for gangrene of the forefoot.

In May 1935, the author attempted to accumulate positive evidence on this problem by injecting various types of chromatic substances into the arterial trees of animals.

As it is being employed at present, arteriochromia is performed in the following manner: The main artery of the upper or lower extremity, femoral or humeral, is palpated and punctured by a long thin needle, directed into the axis of the vessel. Five cubic centimeters of "Pimecral", apparently a proprietary drug, or five cubic centimeters of a 2 per cent. solution of "trypoflavin" are slowly injected. Directly thereafter, discoloration of the skin will be noted in the area of the distribution of the artery. The intensity of the discoloration as well as the upper and lower limits are carefully noted as a guide to the probable area of satisfactory vascularization.—*Henry Milch, M.D., New York, N. Y.*

TRATAMENTO DAS FRATURAS DO COLO DO FEMUR (Treatment of Fractures of the Neck of the Femur). Barros Lima. *Arquivos Brasileiros de Cirurgia e Ortopedia*, XIII, 57, 1944.

A very comprehensive study of fracture of the neck of the femur is given, including the mechanism of fracture and reasons for failure. Various methods of treatment are critically reviewed, and the method of Godoy-Moreira is described in some detail.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

SINDROME DE KLIPPEL-FEIL (KLIPPEL-FEIL SYNDROME). Antonio R. Grasso. *Boletín de la Sociedad de Cirugía del Uruguay*, XV, 198, 1944.

As a result of observations made on a girl, nine years old, in whom torticollis was the primary symptom, the author undertook a review of the Klippel-Feil syndrome. Clinically the cases thus far reported may be divided into:

1. Abortive type, including cases which are symptomless until the diagnosis is accidentally made, following injury or some intercurrent infection;
2. Mild type, including those cases in which torticollis, elevation of the scapula, or cervicodorsal scoliosis constitute the prominent symptoms.
3. Classic type, including the characteristic "man without neck". Clinically this form is characterized by the symptom triad: absence of neck, low implantation of hair, and limitation of motion in the cervical spine.

These symptoms, resulting from the anatomical malformations of the cervical spine, are associated with a number of accessory symptoms: descent of the lobule of the ear; descent of the mammary areolae; descent of the mandible and consequent difficulty in opening the mouth; malformation of the thorax; cervicodorsal scoliosis and kyphosis; and neurological symptoms involving the cranial and peripheral nerves.

Roentgenographically the condition is characterized by: reduction in the number of cervical elements; anomalies, such as spina bifida; vertebral synostosis; aplasia-hemispondylia or platyspondylisis of the cervical vertebrae; reduction in the number of ribs; and sacralization and spina bifida of the fifth lumbar vertebra.

Anatomically, all the variations seen in Klippel-Feil syndrome may be attributed to embryological arrest in development. Apart from those monstrosities which are incompatible with normal existence, the prognosis for life is good. In those cases in which peripheral-nerve symptoms arise from the presence of a cervical rib or an enlarged apophysis, surgery is indicated.—*Henry Milch, M.D., New York, N. Y.*

PLASTICITY OF BONE. James F. Brailsford. *The British Journal of Surgery*, XXXII, 345, 1945.

The features of a perfect model are preserved by the balance of muscular tension and the strength, hardness, rigidity, and resilience of the bone. The features are changed if the balance is upset. As a result, the affected elements bend and certain characteristic deformities are produced, unless steps are taken to neutralize the abnormal influence. Before mineral matter is deposited in pre-osseous tissue, it is plastic, and it can be compressed and deformed by stresses and strains, although it is not altered by such stresses and strains in the normal growing child.

"With the cessation of function, occasioned by paralysis, there occurs a gradual decalcification of the bones of the affected part." This may occur in the spine or in an extremity. In osteogenesis imperfecta there is atrophy of the shafts of the bones with normal growth or overgrowth of the diaphyses. The skeleton shows plasticity, and is altered by muscular or gravitational pull.

Plasticity may be due to generalized changes in the bone, as in osteogenesis imperfecta and in renal rickets, or to changes localized to one portion of the skeleton, as in Paget's disease. Trauma may cause localized plasticity. During some of the stages of osteochondritis the bone is soft and requires protection from weight-bearing.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

OSTEOMYELITIS OF THE CLAVICLE. Tina Gray. *The British Journal of Surgery*, XXXII, 466, 1945.

This is a case report of a boy of twelve. At operation for drainage of osteomyelitis of the clavicle, it was found that the entire bone had sequestrated and it was removed. The boy had no disability following removal, and the wound healed rapidly. Complete regeneration of the clavicle occurred.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

PLASMOCYTOMA OF BONE. William Tennent. *The British Journal of Surgery*, XXXII, 471, 1945.

Plasmocytomata are rare tumors composed of plasma cells or their immediate precursors. They arise in the lymphatic tissue of the nasopharynx and in bone marrow. Plasmocytoma of bone occurs in the marrow of flat bones, long bones, and vertebrae, but has not been reported in the small bones of the hands or feet. The commonest sites are in the ilium and the proximal ends of the femur and humerus. The writer found forty-nine cases reported in the literature, and presents a fiftieth case.

A male of fifty, being treated for pneumonia, was found to have a deep mass in the right iliac fossa, tender to pressure and fixed to the posterior abdominal wall. Roentgenograms showed a destructive process in the right ilium. The cortex was expanded, but not destroyed; and the tumor was limited to the bone.

Biopsy showed a plasmocytoma. Roentgenograms of other bones revealed no other lesions. Roentgenotherapy was advised but refused. The patient was not seen again until two years later, at which time he stated that for three months he had suffered from ache at the site of the original tumor, general weakness, loss of weight, and shortness of breath. At times he had had pains in both arms and legs.

Roentgenographic examination showed multiple areas of rarefaction in the left femur, skull, ribs, and both humeri. These had the typical appearance of multiple myelomatosis. Bence-Jones proteose was present in the urine.

A few weeks later the patient died. From his history it was gleaned that he had had symptoms referable to his hip and pelvis for three years before the tumor was discovered. It was apparent that this process had gone on for five years before it assumed the characteristic picture of multiple myelomatosis. Such a terminal outcome is to be expected, if the original tumor is untreated.

Study of the other cases in the literature shows that they have been treated by radiation, curettage, and amputation. Because of lack of adequate follow-up, no decision can be made as to the best methods of treatment.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

TREATMENT OF WOUNDS BY DELAYED SUTURE. William Patrick. *British Medical Journal*, II, 788, 1944.

In the author's group of three series of cases (ten, twenty-eight, and eighteen, respectively), forty-seven wounds out of fifty-six were healed completely within three weeks of suturing, and twenty-eight of the forty-seven wounds were healed by first intention on the tenth day. Penicillin and sulfonamides were used in combination in the first two series, sulfanilamide alone in the third. The best results were obtained when the two powders were combined.

Causative missiles had been mainly high-explosive shell or mortar shell, but the nature of the missile had no obvious effect on healing; nor was the healing process affected by the location, situation, or direction of the wound. A strong bacteriostatic powder with a longer time interval before suture produced better results in the first and second series than a weaker powder and a shorter time interval in the third series. Occasionally, on the tenth day, a wound was discovered to be a little red and "grumbly" at the stitch holes, but with a firm suture line; this very mild degree of infection never proved to be of any significance, and at the subsequent dressing on the sixteenth day, the wound was usually found to be dry and healed. Extra dressings were done when indicated.

AMPUTATION OF THE EXTREMITIES, AND PROSTHESIS, IN THE U.S.S.R. Nikolai N. Priorov. *British Medical Journal*, I, 178, 1945.

The majority of amputations in the Soviet Army are performed at the front, and only one-fifth in hospitals in the rear. Reasons for amputation include severe destruction and crushing of soft tissue, bones, and joints (up to 40 per cent.), almost complete tearing away of the limb by bomb or shell fragment, gas infection, gas gangrene, and sepsis.

Both chop and guillotine methods of amputation are used, the latter being preferred. Primary amputations are not sutured. Prepared flaps are rolled into tube form and sutured, to be used later. Safeguards obligatory in amputations include heat, blood transfusion, a tourniquet, anaesthesia, and sulfonamides.

Up to 80 per cent. of amputation stumps are diseased or defective. Diseases comprise non-healing wounds, ulcers, osteomyelitis, ligature fistulae, exostosis, neuritis, pains in the stump, phlebitis, disorders of the skin, and contracture. Defects consist of excessively long or short stumps, disarticulated stumps of the knee joint, ankle joint, wrist, and shoulder, stump scars with bone adhesions, conical stumps, ankylosis, and defects following osteoplastic operations. Cases that do not respond to conservative measures are treated by skin-grafting, by grafting adjacent tissue, by excision of scar tissue with skin-grafting, by removal of adhesions and ligatures, by removal of neuromata and neurolysis, by sequestrectomy, or by re-amputation. Indications for re-amputation have occurred in non-healing wounds up to 60 per cent.; in osteomyelitis, from 17 to 20 per cent.; in extensive scars with bone adhesions, 10 per cent.; and for exostosis and pains, 10 per cent. The bone canal, in re-amputation, is tamponed with a section of muscle. The stump is carefully prepared for a prosthesis for two to three months by stump exercises, physiotherapy, gymnastics, stump wrapping, and training to accustom the stump to withstand pressure.

Up to 90 per cent. of amputees, after being treated and supplied with artificial limbs, return to the factories, plants, and other establishments, where they were employed prior to the war.

OSTEOPLASTIC RE-AMPUTATION OF THE THIGH. Alexander Kotov. *British Medical Journal*, I, 179, 1945.

End-weight-bearing stumps are preferred to other types by many Russian surgeons from the prosthetic point of view. Below-the-knee amputations are considered to provide the best means of obtaining end-weight-bearing stumps by operative procedure. The Pirogov, Syme, Bier, and Kirschner operations are used in below-the-knee re-amputations.

In re-amputation of the thigh, the Gritti-Stokes amputation gives a good result in the lower third of the thigh. A new technique has been devised, where this operation cannot be used, to obtain a pressure-bearing thigh stump. A flap of skin sufficient to cover the lower surface of the stump is cut from the anterior aspect of the thigh. The skin on the posterior surface is divided almost perpendicularly to the bone of the extremity. The muscle layers are divided conoidally, and the bones of the thigh are cut through. A ring-shaped bone transplant, 0.5 to 0.75 centimeter thick, is cut from the proximal end of the amputated bone, and is introduced in whole or in sections into the bone-marrow canal. The muscles are then stitched in layers, and the skin is sutured. During ten months of work, fifteen osteoplastic re-amputations of the thigh stump in the middle third were performed by this technique. The postoperative wound healed quickly. On the twelfth to fourteenth day after the operation, daily exercises were begun, to educate the stump to weight-bearing. The amputee was supplied with crutches, fitted with a platform for supporting the stump, at the beginning of the second month after operation. The walking time was increased daily. Later, end-weight-bearing prostheses, having free mobility of the knee joint, were provided.

PERITENDINITIS, OR FOOT-SLOGGERS NODULE. H. Daintree Johnson. *British Medical Journal*, I, 193, 1945.

Peritendinitis presents itself as a painful swelling over a tendon and corresponds to a point of pressure, such as a fold in the leather of a boot. Pain comes on during a march, and the lesion may occur on the Achilles tendon, the tendon of the tibialis anterior, or the flexor tendon of the hallux. It gradually becomes a well-circumscribed elevated nodule, or two nodules with a groove between. The nodule is closely adherent to the skin, but can be lifted off the tendon. The commonest site is over the Achilles tendon. The crease in the soldier's boot projects forward and the lesion is caused by repeated indentation. For treatment, the author suggests stiffening the back of the boot with a tin splint, which is clipped on (illustrations are given).

A nodule over the tibialis anterior tendon is produced by that cross-piece of the lace most nearly opposite to the ankle joint. The soldier should be taught to lace his boots so that the laces do not cross the tendon beneath the leather, but only in front of it. A strip of felt should be inserted behind the tongue of each boot.

If a crease has formed just behind the toe-cap of the boot and caused peritendinitis over the base of the hallux, the lesion may be relieved by the insertion of a piece of felt, which will cause the leather to fold outward instead of inward. The patient may have to be excused from wearing boots altogether or given footgear that does not cause pain.

RECURRENT DISLOCATION OF ANKLE DUE TO RUPTURE OF EXTERNAL LATERAL LIGAMENT. E. Hambly. *British Medical Journal*, I, 413, 1945.

An operation for recurrent dislocation of the ankle due to rupture of the external lateral ligament is reported. The ligament is repaired by splitting the peroneus longus tendon from above downward. The detached end is threaded through the lateral malleolus and through the os calcis, and back again on itself. This reconstitutes the ligament.

A case report is given in which the operation was successful. The patient has had no further trouble.

STABILIZATION OPERATIONS OF THE FOOT. A. K. Basu. *Calcutta Medical Journal*, XXXIX, 9, 1942.

Basu describes and compares seven operative procedures for production of a firm painless foot suitable for weight-bearing and progression. These operations are: (1) Whitman's astragalectomy, (2) Dunn's triple arthrodesis, (3) Hoke's operation, (4) Lambrinudi's operation, (5) subastragalar arthrodesis, (6) Campbell's operation, and (7) Putti's operation. The chief indications for such procedures are: (1) postparalytic flail-foot following poliomyelitis, (2) congenital club-foot, (3) peroneal-nerve injury, and (4) fracture of the talus or calcaneum. The author also reports two cases of astragalectomy, one of Dunn's operation, and two of subastragalar arthrodesis. The article seems of unusual interest.—*Robert M. Green, M.D., Boston, Massachusetts.*

INTERNAL FIXATION OF FRACTURES OF THE NECK OF THE FEMUR. Duncan W. Boucher. *The Canadian Medical Association Journal*, LII, 31, 1945.

The author reports the use of the three-flanged, centrally canalized nail, in the internal fixation of forty-seven fractures of the neck of the femur. Subcapital fracture occurred in 16.2 per cent., transcervical fracture, in 41.8 per cent., and basilar fractures, either intertrochanteric or pertrochanteric, in 41.8 per cent. The ages ranged from fifty-four to eighty-nine years, with most in the eighth decade.

The fractures were more common in women than in men, 83.2 per cent. as compared with 16.7 per cent. Nineteen patients, or 40 per cent., had complications on admission, which affected the end result.

Anaesthesia was induced, in most cases, with nitrous oxide and oxygen; in some, with a spinal anaesthetic; and in one, by local infiltration. Roentgenograms guided the procedure, before, during, and after the operation. Extra-articular technique was followed in the introduction of the three-flanged nail, with the thigh in a position of abduction, hyperextension, and in internal rotation, and with the knee preferably fully extended. The guide wire was inserted well into the head of the femur, and the nail was threaded over the wire, and hammered home. Vigorous movements were then carried out by the surgeon to test the thoroughness of the operative procedure. Smooth movement, without recurring deformity, indicated solid impaction.

Patients were up on about the fourth day, and were bearing weight on the injured limb by the ninth week or sooner.

The end results were good in 72.3 per cent., fair in 8.3 per cent., bad in 8.3 per cent.; and 10.6 per cent. died. No nails were extracted, except in those patients who died while in the Hospital, and in one case of absorption of the neck of the femur.

ESTUDIO DE LA SINAPSA MIONEURAL EXPERIMENTALMENTE Y EN BIOPSIAS DE MÚSCULOS HUMANOS PARALITICOS (EXPERIMENTAL STUDY OF MYONEURAL FUNCTION IN BIOPSY SPECIMENS TAKEN FROM MUSCLES OF POLIOMYELITIC PATIENTS). J. Sanz Ibáñez. *Cirugía del Aparato Locomotor*, I, 193, 1944.

Ibáñez, working in the Cahal Institute, studied the myoneural functions in biopsy specimens, taken from muscles of patients with poliomyelitis and from experimental animals in various stages of the disease. He found two groups of paralyses: (1) paralysis of central origin, irreparable, due to destruction of the nerve cells of the anterior horn of the medulla, (2) paralysis of peripheral origin, reparable, due to changes in the nervous components of the motorial plate. In the second type, regeneration is capable of restoring movement in the paralyzed muscles.

In guinea pigs, febrile infections were found, unaccompanied by paralysis. Other animals were observed, in which there was neither paralysis nor fever. In these cases, the plasma of the animals neutralized the virus of poliomyelitis. The author concludes that three forms of the disease occur: (1) fever with paralysis; paralysis may be central or peripheral; (2) fever without paralysis; (3) disease without either fever or paralysis. Biopsies of muscles in various stages of paralysis showed the development of arborization of nerve filaments, which to the author suggested repair, and explained the recuperation of function in certain cases.—*John G. Kuhns, M.D., Boston, Massachusetts.*

EL SARCOMA OSTEOGENICO (OSTEOGENIC SARCOMA). L. Sierra Cano and F. Lopez Areal. *Cirugía del Aparato Locomotor*, II, 1, 1945.

The authors review the cases of osteogenic sarcoma seen at the Institute of Health at Valdecilla. Thirty patients were seen between 1930 and 1944, seventeen of whom were twenty years of age or less. Trauma played a rather insignificant rôle in the onset. Following the considerations of Segond—previous injury at the site of the tumor, sufficient severity of the injury, development of the tumor in the traumatized tissue, continuity of the relationship between the injury and the tumor (one month to two years)—nine case histories are discussed, in which there was a probable relationship between the lesion and an injury. The tumors studied were located chiefly in the lower extremity, seventeen in the femur, five in the tibia; twenty-four were located about the epiphyseal line. Generalized adenopathy was found in eight cases. Three cases were mistakenly diagnosed as osteomyelitis.

In these patients early surgical intervention was practised. Amputations were performed upon fifteen, and disarticulations upon five. Only three of the patients upon whom amputations were performed lived over two years; and of the five patients having disarticulations, only one lived over two years.

This result is in accord with the statement of Ferguson that early amputation is fatal. It should be deferred for at least seven months from the onset of symptoms. Survival has depended more upon the type of tumor than upon the method of treatment, so that no categorical answer can yet be given in regard to the best treatment.

In seven cases, pulmonary metastases were the first symptoms which the patient showed. The cause of death in all cases was systemic metatases of the tumor.—*John G. Kuhns, M.D., Boston, Massachusetts.*

DISEPIFISIPLASIA VERTEBRAL (EL CIFOSIS DORSAL JUVENIL) [Epiphyseal Dysplasia of the Vertebrae]. V. Sanchis Olmos. *Cirugía del Aparato Locomotor*, II, 97, 1945.

Olmos reviews the histories of twelve cases of juvenile dorsal kyphosis (Scheuermann's disease). He reviews the various etiological considerations: heredity, constitutional weakness, trauma, and endocrine disturbances. The author believes with Schanz that muscular insufficiency predisposes to this condition, which is then followed by cartilaginous deformity. Beginning deformity changes the balance between the stimulus of traction and of pressure. The changes in the intervertebral discs and the marginal proliferation about the bodies follow the earlier epiphyseal changes. The vertebral epiphyses are not such

as are found in long bones, but are secondary nuclei of ossification such as are found in the os calcis. The term juvenile dorsal kyphosis is meaningless. Osteochondritis and epiphysitis are false, since no evidence of inflammation is found. The same can be said of localized malacia. Vertebral epiphyseal dysplasia most completely describes this disturbance. These lesions are of great importance in the development of senile kyphosis and spinal arthritis deformans.

For treatment during the early stages, the author advises rest on a hard bed until pain disappears, the use of heat, massage to the spinal muscles, and local infiltration with novocaine. This is followed by exercises to strengthen the spinal and abdominal muscles. When definite deformity is present, attempts should be made to correct this, or to compensate for it if it is incorrectable. Correction is carried out chiefly by gymnastics and physiotherapy. When severe deformity is present, a corset may be used, as well as heat, massage, and exercises.—*John G. Kuhns, M.D., Boston, Massachusetts.*

INTRAPELVIC PROTRUSION OF THE ACETABULUM. B. N. Balakrishna Rao. *The Indian Journal of Surgery*, VI, 175, 1944.

The author discusses non-traumatic progressive protrusion of the acetabulum and the femoral head into the pelvis. The condition was first described by Otto in 1824 as "an abnormal gouty manifestation". Six new cases of this rare condition are reported, and the roentgenographic aspects are emphasized. Rao believes that it is probably inflammatory in origin, rather than being a developmental anomaly. He particularly recommends in the treatment of this condition Smith-Petersen's operation of acetabuloplasty, reported in *The Journal of Bone and Joint Surgery* (XVIII, 869, 1936), as this prevents further protrusion.—*Robert M. Green, M.D., Boston, Massachusetts.*

OSTEO-SPONDYLOSIS CONDENSANS HEREDITARIA. R. J. Weingarten and G. Politzer. *The Indian Journal of Surgery*, VII, 1, 1945.

The authors describe a hereditary skeletal disease, not previously recognized, for which they propose the name of *osteo-spondylosis condensans hereditaria*. Examination of three brothers revealed bilateral bone changes, consisting of pronounced thickening and condensation of the flat bones and, to a lesser extent, of the long bones. Exostoses and ossification of ligaments and muscle insertions were observed. Concurrent involvement of the central nervous system, simulating the syndrome of amyotrophic lateral sclerosis, was an outstanding feature. In the patients studied, abnormal clinical signs appeared in the third decade of life and progressed in the course of about ten years toward complete invalidism. Excellent roentgenograms illustrate the article.—*Robert M. Green, M.D., Boston, Massachusetts.*

THE TREATMENT OF SPONDYLOLISTHESIS. Walter E. Dandy. *The Journal of the American Medical Association*, CXXVII, 137, 1945.

The author continues to advance his method of spine fusion as the superior means of obtaining stabilization of the vertebrae. This study was begun with the thought that fixation of opposing vertebrae resulting from complete removal of an affected disc at the site of the spondylolisthesis would produce a much simpler and more effective fusion of the spine than the customary fusion with bone grafts. The following unexpected conclusions have resulted from such a study on patients operated upon for spondylolisthesis: (1) that the spondylolisthesis is usually responsible for only part and at times none of the symptoms; (2) that in most (not all) instances it is not the spondylolisthesis or even the disc at its site that causes the symptoms, but rather another disc or discs; and (3) that cure usually depends more upon removal of the other disc or discs than on the one at the site of the spondylolisthesis, though this too must be extirpated.

The principal reasons for these conclusions are listed, and it is the author's impression from his analysis that the spondylolisthesis is but an incident in the field of ruptured discs, and that, on the whole, while it causes its share of symptoms, it causes less than the contiguous disc or discs. The reason for the development of spondylolisthesis is considered to be precisely the same as for defective discs,—that is, the outward shift in the lateral articulations in the lower three lumbar vertebrae, nearly always most pronounced at the fifth lumbar. Here the joint is frequently turned outward 90 degrees from the direction of those at the first and second lumbar vertebrae, and in addition the joint is sometimes flat and vertical and with little or no flanges to keep the joint surfaces from slipping. The signs and symptoms of spondylolisthesis are precisely the same as those of defective discs without spondylolisthesis; only the roentgenographic appearance makes the differential diagnosis.

He then enumerates his points of dissatisfaction with spine fusion by autogenous grafts: (1) It is a prolonged major operative procedure; (2) it is necessary for the patient to be hospitalized in a cast for two or three months; (3) many grafts are unsuccessful and many absorb; (4) infection is a real danger, with frequent loss of all of the graft, making subsequent operation for removal of discs difficult; and (5), the graft is contra-indicated and useless because it merely covers up the offending discs and adds nothing to the fusion that follows complete removal of the discs. Following the author's disc operation, there is no need for a cast, the patient can leave the hospital in a week to ten days, and a light corset is advised for two or three months.

The three most important items in the author's treatment by removing the discs are: the complete removal of the affected discs; the recognition of multiple disc involvement; and the recognition of small (concealed) disc lesions. These three items are enlarged upon, and should be read in the original by all interested in the disc problem. Experiences similar to those of Dandy, if reported from another clinic, would strengthen the many assertions made by him, and should prove an advance in the care of these patients.—*H. H. Beckering, M.D., Dallas, Texas.*

ONE STAGE COMBINED RESECTION OF THE RIBS AND SPINAL FUSION FOR SEVERE SCOLIOSIS. William H. Bickel, John J. Hinchey, and O. Theron Clagett. *The Journal of the American Medical Association*, CXXVII, 139, 1945.

This paper is based on eleven cases of scoliosis in which resection of ribs and immediate spine fusion were performed to correct the deformity of the thoracic wall and arrest the scoliosis. The ages of the patients varied from eleven to twenty-two years; the average age was sixteen years. Three patients had congenital scoliosis, one, as a result of poliomyelitis; the remaining seven cases were idiopathic. Previous treatment had consisted of the usual conservative orthopaedic measures. The eleven cases were operated upon over a period of thirteen years; the last eight, in the past four years.

Preoperative treatment consisted of traction applied to the head and feet on a hyperextension frame for about ten days. Postoperatively, the patients were kept on a straight Bradford frame for the next four weeks. Then a body jacket was applied with the aid of the Goldthwait frame, after which the patient was ambulatory for one week. After these seven weeks, a cast extending from the chin and occiput to the iliac crests was applied under vertical suspension. This cast was worn for about four months. This was followed by a corset or Taylor brace for another six months, at which time swimming and breathing exercises were begun.

No correction of the curve by turnbuckle jackets or like methods was attempted. The number of involved ribs ranged from three to six. Usually from two to five inches of the ribs was resected, depending upon the relation of the rib to the convexity of the curve. The number of vertebrae fused ranged from eight to fourteen,—the whole thoracic vertebral curvature was grafted in each instance. Lumbar vertebrae were included in the grafting procedure in all but two cases.

Blood transfusions were used as indicated. The only complication was pleural effusion in three cases. In all cases, bone fusion was complete at the end of six to nine months. When there was regeneration of the resected ribs from the periosteum, the new portion conformed to the corrected contour of the thoracic wall.—*Brandon Carrell, M.D., Dallas, Texas.*

THE CLINICAL DIAGNOSIS, PROGNOSIS AND TREATMENT OF ACUTE HEMATOGENOUS OSTEOMYELITIS. Frank D. Dickson. *The Journal of the American Medical Association*, CXXVII, 212, 1945.

The facts presented by the author are based on a study of 295 cases of acute hematogenous osteomyelitis treated over a period of the last fifteen years. The staphylococcus is the offending organism in about 90 per cent. of the cases, usually the hemolytic staphylococcus aureus. The next most common organism found in culture is the streptococcus; occasionally a pneumococcus is found. In children under two years of age, the streptococcus is far more frequently found,—from 40 to 50 per cent.

The pathogenesis of the bone lesion is thoroughly discussed, and is clearly outlined; the theories as to the reason for the location of the bone abscess are explained. The clinical picture of the patient is well described and discussed. The usual laboratory findings are mentioned, and the differential diagnosis consists of: pyarthrosis, cellulitis, and rheumatoid arthritis.

The prognosis depends upon whether the case is one in which there is a transient bacteriaemia with the formation of a local bone abscess, or whether it is one in which a true septicaemia is present with pyaemia. In the former, the prognosis as to recovery is good; in the latter, it is grave, and a fatal outcome is a frequent result. The prognosis, so far as healing of the local bone focus is concerned, is poor. A great majority of the patients three years of age or older pass on to the chronic stage; in infants, however, there is little tendency for the disease to become chronic. The difference in the behavior of bone in extremely young children compared with older children and adults has been considered due to the following: The infection in young children is frequently a streptococcus; the large cancellous spaces in the bones of the infant allow the infection to pass more readily from the site of origin into the subperiosteal space, and the periosteum, being loosely attached in the infant, separates readily or ruptures, thus affording early drainage for the infection and ensuring minimal bone destruction; dead bone in young children absorbs very quickly, and formation of new bone is rapid.

Treatment in the infant should be directed toward the patient as a whole, and should be conservative, little attention being paid to the bone. Supportive treatment, prevention of dehydration, and immobilization of the extremity are the essentials. Antistaphylococcus serum should be administered, and the sulfonamides or penicillin should be used. Local treatment of the bone should be guided by the pathology present. Drainage by aspiration, incision and drainage of the soft-tissue abscess, and drilling and drainage of the bone are the means at hand, and they should be as conservative as possible.

Treatment in children over two years of age, in adolescents, and in adults should be carried out

along several lines,—general supportive measures, chemotherapy, administration of staphylococcus antitoxin, and management of the local bone disease. Parenteral fluids and blood transfusions, relief of pain by analgesics or opiates, staphylococcus antitoxin, sulfonamides, penicillin, and possibly bacteriophage should be used.

The differences of opinion as to the management of the local bone disease in these older patients are discussed. The author favors drainage of the bone abscess as soon as septicaemia is controlled and the general status is good.—*D. K. Barnes, M.D., Dallas, Texas.*

Aseptic Necrosis of the Epiphyses and Short Bones. Roentgen Studies. Howard P. Doub. *The Journal of the American Medical Association,* CXXVII, 311, 1945.

Areas of necrosis involving the epiphyses and also the primary centers of ossification in certain of the short bones have been described by different observers, and the name of the original observer has been attached to the lesion. These diseases have been known also under more general headings,—such as, epiphysitis, osteochrondritis, and subchrondral necrosis. It is now generally accepted that they represent the same underlying pathological process, although there is no general agreement as to the exact etiological agent.

The following are the theories advanced to explain the occurrence of areas of necrosis in the short bones and epiphyses: endocrine dysfunction; trauma; vascular occlusion, induced by trauma; and embolic vascular occlusion. These lesions are considered to be those of aseptic necrosis. There is actual death of the ossifying nucleus, which is followed by fragmentation, irregular absorption, and finally by replacement through so-called creeping substitution or recalcification. The necrotic bone in children is nearly always replaced by new bone, and the replacement proceeds more rapidly than in adults. The cartilage may show evidence of nutritional disturbance in places, but in large part it remains alive and may become thicker than normal, taking part in further epiphyseal growth after the necrotic bone has been replaced.

The author discusses concisely the following: osteochrondritis deformans juvenilis of the femoral head; slipping of the upper femoral epiphysis; epiphysitis of the tibial tubercle; aseptic necrosis of the tarsal scaphoid; infraction of the head of the second metatarsal; and kyphosis dorsalis juvenilis. No additional knowledge is presented, but this article is an excellent review of the subject.

A list of the various lesions, and the date of the first description of each by the author given the credit for its discovery, is included and is very interesting and valuable.—*D. K. Barnes, M.D., Dallas, Texas.*

The Clinical Diagnosis, Treatment, and Prognosis of Epiphysial Disturbances in Childhood. Wallace H. Cole. *The Journal of the American Medical Association,* CXXVII, 318, 1945.

The roentgenological aspects of this subject having been ably presented in the paper by Doub, the present author has confined himself to the clinical aspects and management of the various osteochrondroses, as they are officially termed.

Osteochrondrosis of the femoral head is common, and is often diagnosed by the family physician on the clinical findings. About 85 per cent. of the cases occur in males from three years to teen age; an onset after the age of twelve is very rare. The clinical findings are reviewed, and the various means of treatment by non-weight-bearing by the softened femoral head are presented. Prognosis depends upon the amount of deformity of the femoral head produced by weight-bearing.

Slipping of the proximal femoral epiphysis may be confused clinically with osteochrondrosis of the same epiphysis, but it occurs twice as often in boys as in girls; and, in about 70 per cent. of the cases, the body build resembles that of the Fröhlich type of individual. The smaller percentage of patients are apparently normal physically, or are the tall, thin, and rapidly growing type. The posterior and inferior displacement of the head is corrected by strong skeletal traction, by manipulation, by open reduction, or by osteotomy of the neck of the femur. The position must be maintained until the epiphysis closes, and this may be hastened by various procedures. Prognosis depends upon the correction obtained, and upon the configuration of the joint components.

Vertebral epiphysitis does not occur until puberty, as the epiphyseal plates develop at that time. Most cases are seen in boys between fourteen and seventeen years of age. The usual symptoms and findings are reviewed. Treatment is directed toward the prevention or correction, if possible, of the deformity of the increased dorsal kyphosis, until the spinal epiphyses unite with the bodies of the vertebrae.

Osteochrondrosis of the tibial tubercle is seen usually in active adolescent boys and does not lead to permanent disability. The signs and symptoms are reviewed, and the various means of treatment, aimed at relieving tension on the patellar tendon, are presented. Apophysitis of the os calcis never has any residual disability, and it is treated by reducing the pull of the tendo achillis. Osteochrondrosis of the head of the second metatarsal is treated by rest and protection until the epiphysis unites, when there is no longer any disability.

The author recommends the concomitant use of thyroid, although he does not believe it to be a specific. In the discussion of these papers, W. Edward Chamberlain questioned the use of the term aseptic necrosis for the various osteochrondritides. Dallas B. Phemister defended the use of the term necrosis and briefly reviewed the pathology.– *Brandon Carrell, M.D., Dallas, Texas.*

RASSASIVAUSHYSIA METALICHESKY SPLAV "OSTEOSINTESIT" KAK MATERIAL DLIA SKREPLENIA KOSTI PRI PERELOMACH (An Absorbable Alloy, "Osteosynthesit", as a Material for Bone Fixation in Fractures). V. V. Troitsky i D. N. Zitrin. *Khirurgyia,* VIII, 41, 1944.

An alloy bearing the name of osteosynthesit was made by the authors. Their intention was to create a metal capable of absorption by the end of the period of consolidation in fractures.

The alloy consists of magnesium, with the addition of minute quantities of cadmium. Experimental investigations showed that the osteosynthesit plates introduced into the animal body immediately reacted with the surrounding tissues, producing magnesium salts and free hydrogen. No local irritation occurred, however. The formation of magnesium salts stimulated the development of bone callus. The rate of absorption for a plate two millimeters thick is such that it retains its mechanical efficiency for from six to eight weeks in wounds with normal acidity. The plate is completely resorbed in from ten to twelve months.

In wounds with increased acidity the rate of absorption is hastened, but so is the rate of bone consolidation. In the presence of neutral or alkaline reactions, the plates either do not absorb or the resorption is very slow. The authors state that out of thirty-four reported clinical observations, twenty-five were successful; the remaining nine were not satisfactory. However, the cause of failure in the nine cases could not be attributed to the alloy.

Further experiments are being conducted by the authors with various nails, screws, plates, hooks, wire, and hemostatic clips for the brain, and some of these have already been used successfully in human surgery.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

A NEW METHOD OF DIGITAL SKELETAL TRACTION. Thomas B. Quigley and Marshall R. Urist. *Medical Bulletin of the Office of the Surgeon, European Theatre of Operations* (Publication Restricted to Officers of the United States Army), No. 30, p. 56, Apr. 1945.

The authors point out the disadvantages of the various devices in common use for digital skeletal traction, and describe a new technique which they have devised and found satisfactory in their experience with over fifty fingers.

The absence of important structures in the middle third of the dorsum of the middle phalanx permits insertion of the authors' skeletal traction device. Through a very short incision in the skin, and under local anaesthesia, a small drill hole is made through the cortex of the dorsum of this phalanx, and a piece of wire, bent to the shape of a fishhook (or a small No. 4 fishhook, the barb of which has been removed), is inserted into the medullary cavity of this phalanx. Elastic traction is applied to a loop at the end of the shank of the hook-shaped wire. Motion of the metacarpophalangeal joints is carried out passively by the surgeon, through a complete range of motion, ten or fifteen times daily, beginning from five to seven days after the insertion of the hook. Active exercise of the interphalangeal joints is instituted, under supervision, as quickly as the condition of the hand permits. The usual roentgenographic check of the position of the fragments is carried out, and the tension and line of pull of the elastic are adjusted to correct angulation or distraction.

TENOSUSPENSION OPERATION FOR HABITUAL DISLOCATION OF THE SHOULDER. M. S. Henderson. *Proceedings of the Staff Meetings of the Mayo Clinic,* XIX, 5, 1944.

The author reports fifty-five tenosuspension operations for recurrent or habitual dislocation of the shoulder. The operations were performed over a period of nineteen years. The primary cause of dislocation varied greatly, including almost every conceivable type of trauma. The operation is an extra-articular suspension accomplished with the aid of a free transplant of the peroneus longus tendon. The tendon is used because it is stronger and handled more easily than fascia lata.

The technique of the operation is as follows: The incision through the skin may be of the saber type, two straight incisions, one in front and one posteriorly, or four small incisions. Next, holes are drilled through the tip of the acromion process and through the head of the humerus. The latter hole should be sufficiently far out on the greater tuberosity to prevent opening the joint. After the drill holes are made, the tendon transplant is removed from the leg, via two small incisions, one just above the outer border of the foot where the peroneus longus tendon crosses to the plantar aspect, and the other ten centimeters above the lateral malleolus. The tendon is then severed above in a Z fashion and drawn out through the incision below. Half of the diameter of this tendon can then be taken; it should be six to eight inches long. The remaining portion of the tendon is replaced and is resutured at the site of the Z of the proximal portion of the peroneus longus. The piece of tendon removed is threaded through the previously prepared drill holes. With the arm at the side, the tendon is sutured together after a fair amount of tension is placed on the structure. Care is taken that the tendon transplant is deeply placed

beneath the deltoid muscle and rests snugly down on the joint capsule. Thus two suspensory ligaments are constructed, one anterior and one posterior.

The patient is put to bed, and a sling holds the arm to the side. No abduction is permitted for about two weeks, and then only 20 to 25 degrees. Right-angle abduction is not allowed for three months.

Of fifty-five operations on fifty-one patients, fifty, or 91 per cent., were successful. The average age was 25.6 years. There were eleven females, and forty males. There was little if any restriction of motion. In this group the time interval since the operation varied from fifteen months to nineteen years. Three failures in this series were in epileptic patients.—*J. L. LeNoir, M.D., Iowa City, Iowa.*

SIGNIFICANT SKELETAL IRREGULARITIES OF THE HANDS. John F. Holt and Fred. J. Hodges. *Radiology*, XLIV, 23, 1945.

Routine roentgenographic examination of the hands is as valuable a diagnostic procedure as ophthalmoscopy in the recognition either of generalized systemic disease or of a localized pathological process in some remote portion of the body. Great care should be used in making the films so as to produce a result of the greatest value. Todd's monograph on skeletal maturation of the hand is not only a valuable means of determining bone development, but also constitutes an excellent norm to be used for comparative purposes.

Many endocrine disturbances are revealed by bone changes in the hands. Acromegaly presents broad spade-like hands with overgrowth of the terminal phalangeal tufts, prominence of bony protuberances along the shafts of the metacarpals and phalanges, and a peculiar soap-bubble pattern of distorted trabeculae in the bone ends. Cretinism is revealed by delayed epiphyseal ossification, and by bands of increased density in the ends of the tubular bones. Response to therapy is indicated by subsidence of these changes. Mongolian idiocy can be differentiated from cretinism on the basis of bone changes alone. In mongolism the findings are those of relatively normal bone development and congenital shortening of the middle phalanx of a stubby curved fifth finger. Other findings of endocrine disturbances are: the fibrocystic bone lesions of hyperparathyroidism and of polyostotic fibrous dysplasia; and the peripheral degenerative changes of progeria.

Congenital anomalies as seen in the hands are not only local changes, but may also be a part of more widespread disturbances. Dysostosis cleidocranialis shows characteristic changes in the hands. The ungual phalanges are short and cone-shaped. There is also failure of development of the usual prominent cancellous tufts. The metacarpals, as well as the proximal and middle phalanges, have supernumerary epiphyses which fuse earlier in life than do the normal. All epiphyses appear broader than normal, particularly in the terminal phalanx of the thumb. In achondroplastic dwarfs, the second to fifth metacarpals are short, stubby, of nearly equal length, and the ends are often quite bulbous. The phalanges likewise are short and broad. In Morquio's disease, the ends of the metacarpals and phalanges are grossly irregular, and the carpal bones display a crenated appearance as well as delayed skeletal development. Hurler's syndrome (gargoylism) shows short broad metacarpals, middle phalanges with an arrowhead configuration, and a coarse prominent trabecular pattern. Arachnodactylia is striking because of the exceedingly long metacarpals and phalanges, and the presence of supernumerary epiphyses. In this disease, congenital dislocation of the lenses of the eyes, and congenital heart disease should be looked for.

The majority of changes seen in trophic disturbances are quite similar, and consist in slow spontaneous amputations of the phalanges. In addition to this type of resorption, there may be scleroderma and calcinosis, as well as extensive osteoporosis of the juxta-articular portions of the phalanges and metacarpals, soft-tissue contractures, and soft-tissue calcium depositions.

Chronic granulomata may be local lesions of the hand or may serve to direct attention to a systemic involvement, as in spina ventosa or tuberculous dactylitis. Boeck's sarcoid and osteitis tuberculosa multiplex cystica are more likely the same lesion, and have only an obscure relation to tuberculosis. These lesions are not always punched-out and cystic in character, but may begin merely as a coarsening of the bony trabeculae, following which areas of both cortical and central destruction appear.

Chronic pulmonary or mediastinal disease reveals itself readily in the fingers as pulmonary osteoarthropathy. In addition to the soft-tissue clubbing, periosteal proliferation is noted along the shafts of the metacarpals and phalanges. Its occurrence is greater in non-tuberculous lesions. Since its progression, regression, and severity vary with the course of the chest lesion, roentgenograms of the hand can be used as an indication of the course of the thoracic lesion. These changes are particularly noted in the periosteal proliferation.

Though the moth-eaten lesions of leukaemia are more commonly seen in the long bones, they may also be seen in the hands. In erythroblastic anaemia, the findings in the hands are clear-cut. The metacarpals and phalanges take on a characteristic rectangular shape; the medullary canals are dilated; the cortices are thinned; and the shafts are traversed by a coarse irregular meshwork of dense, broadened trabeculae standing out against the background of osteoporosis.

The chronic arthritides have their characteristic lesions. Gout shows its typical intramedullary and extramedullary destruction secondary to tophi. Chondromata when seen should direct attention to

other bones in the body. Osteopoikilosis, osteopetrosis, and melorheostosis are seen. Tuberous sclerosis sometimes produces rarefactions in the phalanges.

The authors include with the article a series of roentgenograms illustrating many of these findings. —*William H. Wright, M.D., Santa Monica, California.*

Tuberculosis of the Greater Trochanter and its Bursa. P. C. Briede. *Radiology*, XLIV, 32, 1945.

Tuberculosis of the greater trochanteric bursa is rare, and is usually secondary to tuberculous osteomyelitis of the greater trochanter, which itself is often associated with tuberculosis elsewhere in the body, either active or inactive. Wieting in 1904 demonstrated the presence of the tubercle bacillus as the etiological agent in trochanteric bursitis, declaring that the primary infection spread from the trochanter to the bursa.

The condition has been found in all ages and in both sexes. Trauma was thought to be the most constant precipitating factor. The usual complaint was mild pain in the involved leg over a long period of time. Slight swelling was present behind the greater trochanteric area, with tenderness to pressure. There was no heat or redness. Weight-bearing was usually painless, and motion of the hip was free. However, on extension into the neck and hip joint, motion was limited, and weight-bearing was painful. Draining sinuses were common. Active or inactive tuberculosis in other portions of the body was a common finding. Early roentgenographic evidence consisted of a small fleck of calcium in the bursa, or a minimal area of destruction in the trochanter. (These findings are best demonstrated with a soft-tissue technique.) The later and more usual appearance on the roentgenogram was: an area of destruction in the greater trochanter, with an area of osteoporosis in the shaft; soft-tissue swelling, with deposition of calcium; and occasionally a sequestrum lying adjacent to the trochanter. Simple inflammatory bursitis is differentiated by the acuity of symptoms, and the rapidity of response to simple therapeutic measures. Non-specific osteomyelitis of the trochanter may be identical in appearance, but the past history is indicative.

Effective therapy consists in total excision. When the disease is limited to the bursa or involves only a small portion of the trochanter, excision results in cure. Recurrences are common in a high percentage of the cases. Extension into the hip joint is a serious complication. Four cases are presented to illustrate these points.—*William H. Wright, M.D., Santa Monica, California.*

Contribución al estudio de la luxación de rótula (Dislocation of the Patella). L. Sierra Cano y A. Sánchez Trallero. *Revista Española de Cirugía, Traumatología y Ortopedia*, I, 112, 1944.

The authors refer to the lack of unanimity as to the nomenclature, the pathomechanics, or the treatment of dislocation of the patella. It is a rare deformity, only two cases having been observed among 1,800 patients in the authors' clinic. They prefer Buzby's classification of congenital, traumatic, and structural (following poliomyelitis, rickets, and genu recurvatum). Exaggeration of physiological valgus tends to dislocation; but dislocation is also seen in genu varum. Aplasia of the external condyle is another etiological factor, as may be the small size of the patella. Internal torsion of the lower end of the femur is sometimes found. Alterations in the ligamentous apparatus, such as rents in the articular capsule, contracture of the soft parts, and shortening of the vastus lateralis and iliotibial band, are also causative factors. The different causes play a part in various cases.

Indications for treatment vary according to the period of evolution and the seriousness of the lesion. Operation is indicated only at the first appearance of disturbance in function, and not when the deformity is first discovered, because frequently it causes no symptoms throughout life. Conservative treatment of congenital dislocation of the patella consists in physiotherapy for the quadriceps apparatus. Many operations have been described stressing one pathological lesion,—such as osteotomy of the femur, correcting the valgus and the rotation, and raising the external femoral condyle, which is a difficult procedure and leaves much to be desired; it should not be used before growth is completed. There are several operations on the capsular ligamentous apparatus. Capsulorrhaphy has not given good results. Anchoring of the patella by fascia lata to the internal condyle has been successful. Following its introduction by Roux in 1888, many surgeons have transplanted the patellar tendon. This has been criticized, because it may limit the power of extension of the patella.

The authors' two cases are reviewed in detail. One patient was a boy of eight years, with frequent dislocation of the patella. There was no valgus or flattening of the condyle. A myoplastic procedure at the expense of the vastus medialis held the patella in good position, and a good functional result was obtained.

A second patient, eighteen years of age, had had two dislocations. There was no arthritis or functional alteration. Therefore, intervention was not indicated.—*John G. Kuhns, M.D., Boston, Massachusetts.*

La Osteoperiostitis Brucelósica (Osteoperiostitis in Brucellosis). Carlos A. Videla y José A. Scodeller. *La Revista de Medicina y Ciencias Afines*, VI, 893, 1944.

Most of the cases of brucellotic osteoperiostitis are due to brucella melitensis. The chief symptom is pain, usually about one of the joints. It may appear at any stage of the disease. The joints most fre-

quently affected are the spine and sacro-iliac joints, and there the disease process produces an osteitis of the vertebral body, with a flattening or loss of disc space, and occasionally a paravertebral abscess. It is comparable to Pott's disease. Sciatica may accompany sacro-iliac involvement.

Osteitis and osteoperiostitis are less common. Clinically, such conditions occur as inflammatory swellings along the shafts of the long bones. Occasionally, a purulent collection forms, which may drain spontaneously or have to be drained, but which usually regresses spontaneously. The inflammatory reaction in the medullary canal produces the deep-seated, boring pains.

Pathologically, the first phase of osteoperiostitis is a mild decalcification of the cortex, around which a thickened sleeve of periosteum forms. Sequestration does not occur. As the lesion heals, the periostitis may undergo regression, or may result in hyperostotic periostitis. Some cases are accompanied by a "cold" abscess, and others by an acute "pyogenic" swelling, depending on the virulence of the organism.

In addition, the authors report a case of brucellotic periostitis, in which the periostitis in the long bones occurred and disappeared with each febrile reaction. This is extremely unusual.—*Victor Richards, M.D., San Francisco, California.*

LUXATIONS PÉRILUNAIRES RÉCENTES (Recent Perilunar Dislocations). R. Soeur. *Revue d'Orthopédie et de Chirurgie de l'Appareil Moteur,* XXVII, 5, 1941.

To eliminate confusion in the nomenclature of traumatic displacements of the lunate bone, the author groups them under the name of perilunar dislocations. These are divided into displacements of first, second, and third degree.

In the first, the lunate bone retains its relation to the distal end of the radius, but loses contact with the head of the capitate. In the author's series, these dislocations were always accompanied by fractures of the scaphoid. Closed reductions were usually obtained, although immobilization was prolonged on account of the scaphoid fracture.

In the second-degree dislocations, the lunate is enucleated from under the radial articular surface, but still remains in front of its normal place in the carpus, because the anterior radiolunar connection is not torn. These dislocations were observed without fractures of the scaphoid, but constantly presented signs of pressure on the median nerve. These fractures of the scaphoid required open reduction with immobilization for a short time.

In the third group, the lunate is completely dislocated along the surface of the radius, losing contact with the carpus because the ligaments are completely torn. The dislocation is always accompanied by additional fractures and dislocations of one or more bones of the carpus.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

LE TRAITEMENT DU PIED CONVEXE VALGUS CONGÉNITAL (Treatment of Congenital Convex Pes Valgus). J. Leveuf. *Revue d'Orthopédie et de Chirurgie de l'Appareil Moteur,* XXVII, 129, 1941.

The name of the deformity was proposed by Lamy and adapted by the author for reasons of analogy and difference with the known deformity of talipes planovalgus.

The characteristics are: An equinus of the hind foot; dorsiflexion of the forefoot, the axis of rotation being in the midtarsal joints; strong abduction of the metatarsals in relation to the hind foot, creating a concavity of the external border of the foot and a convexity of the medial border, centered over the head of the astragalus.

The author recommends a two-stage procedure:

1. Lengthening of the retracted peroneal tendons and the common extensors. Wedge osteotomy with a medial base of the midtarsal joints. Reinsertion, under tension, of the tendon of the tibialis posterior muscle. In case of severe pronation of the forefoot, a transplantation of the common extensor to the medial side of the foot may be useful.

2. Lengthening of the Achilles tendon for correction of the equinus.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

A PROPOS DE 21 CAS D'OSTÉOCHONDRITE DE L'ÉPIPHYSE FÉMORALE SUPÉRIEURE "COXA PLANA" (On Twenty-One Cases of Osteochondritis of the Upper Femoral Epiphysis—Coxa Plana). J. Bouquier, J. Clénet, et H. Leveau. *Revue d'Orthopédie et de Chirurgie de l'Appareil Moteur,* XXVII, 285, 1941.

According to the study made by the authors, osteochondritis of the superior femoral epiphysis is a non-inflammatory, acquired disease. It follows a congenital malformation of this region and is due to several elements of a predisposing anatomical nature. The acetabulum is congenitally the most frequently affected, next the head, and then the neck of the femur. Due to the congenital malorientation, the normal axis of the hip joint is changed. With the beginning of standing and walking, constant mild trauma takes place, which has repercussions on the contiguous bones of the joint, because the axis of the joint is not normal. Accidental injury aggravates the condition. If the central artery of the femoral head and the nerve supply to the joint are affected, the venous circulation becomes involved, suddenly or gradually. The veins of the head and neck have no anastomoses in early childhood. This functional disturbance of the return circulation is responsible, according to the authors, for the lesions characteristic of epiphysitis of the upper femoral epiphysis. Reorganization of the venous return takes place slowly.

During this period of evolution, however, the softened head is compelled to abandon the irregular acetabulum in part, and to adapt itself to a new joint.

Thus the head of the femur, deformed by osteochondritis, is in itself not a coxa plana, but a late adaptation of an osteochondritic head to an acetabulum flattened by coxa plana.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

LA SECTION DES BRANCHES ARTICULAIRES DU NERF OBTURATEUR DANS LE TRAITEMENT DE L'ARTHRITE CHRONIQUE DE LA HANCHE (Division of the Articular Branches of the Obturator Nerve in the Treatment of Chronic Arthritis of the Hip). L. Tavernier et P. Truchet. *Revue d'Orthopédie et de Chirurgie de l'Appareil Moteur,* XXVIII, 62, 1942.

The authors report their results in twenty-one patients with painful chronic arthritis of the hip, relieved of pain by a single division of the obturator nerve supplying the capsule. In nine patients the result was very good, seven were completely relieved of pain, two were improved, and in only three was there complete failure.

The procedure is indicated in all forms of chronic arthritis—with pain, alone or accompanied by congenital deformity, due to trauma, or secondary to operative interference. The results obtained are immediate and remain satisfactory.

The purpose of the operation is to eliminate the sensory nerve supply to the capsule. The method was first proposed by Camitz in 1933; the first patients were operated upon by the authors in 1936.

The nerves supplying the capsule of the hip joint have posterior branches (from the sciatic, posterior cutaneous nerves, and the nerve of the quadratus femoris), and anterior branches (from the femoral and obturator nerves).

The most important branches transmitting sensory stimuli come from the deep ramus of the obturator nerve in its passage through the obturator foramen.

The obturator nerve is approached through an incision from below the pubic spine to the apex of Scarpa's triangle. The saphenous vein is retracted, and the space between the long adductor and pectineus muscles is located. On separating those two muscles, one finds the superficial branch of the obturator spread on the surface of the adductor brevis. Following this branch upward, the deep branch of the obturator is located and avulsed by rolling it around the jaws of an artery forceps.

In the opinion of the reviewer, this procedure may be of great practical interest.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

LES LÉSIONS DE LA TÊTE DU FÉMUR PROVOQUÉES PAR LES TENTATIVES PROLONGÉES DE REDUCTION ORTHOPÉDIQUE DANS LES LUXATIONS CONGÉNITALES DE LA HANCHE (Lesions of the Head of the Femur in Congenital Dislocation of the Hip Produced by Prolonged Conservative Orthopaedic Treatment). J. Leveuf et R. Leroux. *Revue d'Orthopédie et de Chirurgie de l'Appareil Moteur,* XXIX, 65, 1943.

The relationship of deformity of the head of the femur to closed reduction of congenital dislocation of the hip is not well established. There are few reliable reports based on actual microscopic studies of the deformed heads of the femur.

The authors made a microscopic study of biopsy material from seventeen patients. In fourteen patients, competent orthopaedic surgeons made several attempts toward closed reduction with long immobilization, but perfect reduction was not obtained in any instance. The patients were subsequently operated upon, and a biopsy of the cartilage of the head was done in each case. The material thus obtained constituted the subject of this study. For purposes of control, a biopsy was performed on three patients who had an open reduction immediately following the first unsuccessful attempt at closed reduction. In the three control cases, the cartilage was found to be normal. The fourteen patients treated were divided into three groups: (1) those immobilized after reduction of from four to twelve months; (2) those immobilized for from ten to sixteen months; and (3) those immobilized for from fourteen to thirty-nine months. After these periods of immobilization, it was found that the femoral heads were all deformed. In each group there were typical pathological changes of the cartilage.

The authors believe that the abnormal changes of the head are not due to injuries of the round ligament or synovia, but to prolonged pressure exerted on imperfectly reduced femoral heads.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

LES FORMES ATYPIQUES DE L'OSTÉOCHONDRITE INFANTILE DE L'ÉPIPHYSE FÉMORALE SUPÉRIEUR (Atypical Forms of Infantile Osteochondritis of the Upper Femoral Epiphysis). A. Aimes. *Revue d'Orthopédie et de Chirurgie de l'Appareil Moteur,* XXIX, 78, 1943.

The author describes six types of osteochondritis, besides the usual well-known type.

The usual type is characterized by flattening of the epiphysis, which becomes fragmented and broadened beyond the femoral neck. The epiphyseal plate is wavy and irregular, and the neck is shortened and enlarged. (Twenty-seven patients with these symptoms were followed.)

In addition, the author describes the hypertrophic type which presents, when healed, a very large, round head. Sometimes the head is larger than the acetabulum, and in these cases a secondary shelf is observed. Fourteen patients of this type were observed.

Another type is characterized by very long evolution, with no definite signs of healing for four or five years.

Calvé described a type with acute onset. Four patients of this type who were treated by the author had intermittent attacks of pain, in one instance accompanied by fever.

The author describes an acetabular type of osteochondritis, not involving the head. Seven patients in this group are mentioned.

Six patients tending to develop stiffness and ankylosis of the hip were also observed.

The sixth type is associated with congenital dislocation, and may be of the usual, or hypertrophic, form. Ten cases of this group were seen by the author, of which two were of the hypertrophic type.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

L'OSTÉOTOMIE SOUS-TROCHANTÉRIENNE INDICATIONS—RÉSULTATS (Subtrochanteric Osteotomy: Indications and Results). R. Charry et G. Charry. *Revue d'Orthopédie et de Chirurgie de l'Appareil Moteur*, XXIX, 99, 1943.

Thirty osteotomies in twenty-five patients are reported. In twenty-four cases angulated plates were used for osteosynthesis.

The following are the conclusions of the authors based on twenty-four excellent results, one satisfactory, three doubtful, and two failures:

1. Osteotomies without bone fixation may lead to failure.

2. In cases of arthritis deformans, in addition to the osteotomy, a resection of the obturator nerve is very important.

3. It is important to immobilize both hips in plaster. The immobilization of the normal side should be maintained for at least twenty days.

4. One of the annoying complications is stiffness of the knee on the affected side, which should be prevented by early physiotherapy.

5. If the plating is satisfactory and the bones are not unusually porous, immobilization should not extend beyond forty-five days. After sixty-five or seventy days the patient should be able to walk.

6. In osteotomies for old dislocations of the hip or for pseudarthrosis of the neck of the femur, the angulation after osteotomy should be at least 90 degrees.

The operation is indicated in unreduced congenital dislocations, in arthritis deformans, irreducible traumatic dislocations, and pseudarthrosis of the neck of the femur.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

TRAITEMENT DES SUBLUXATIONS CONGÉNITALES PRIMITIVES DE LA HANCHE CHEZ L'ENFANT (Treatment of Primary Congenital Subluxation of the Hip in Children). M. J. R. Barcat. *Revue d'Orthopédie et de Chirurgie de l'Appareil Moteur*, XXIX, 129, 1943.

The treatment of congenital subluxation depends on the age group of patients. The author recognizes three groups: (1) from birth to eighteen months; (2) eighteen months to eight years; and (3) eight to fifteen years.

In the first group, the treatment is prophylactic. In the presence of signs of femoral mobility, as indicated by the methods of Putti and Hilgenreiner, the treatment by abduction is indicated. In the presence of shallow acetabula only, the patient is kept under observation without treatment but with roentgenographic control every three months; he is not permitted to walk until complete restitution of the acetabula has taken place.

In the second group, the author believes that conservative treatment is entirely unsatisfactory. Operative treatment at the earliest possible age is recommended. The purpose of the operation is replacement of the head in the acetabulum, with a corresponding correction of the valgus and anteversion, by an appropriate wedge resection of the base of the neck.

In the third group, the author divides the treatment according to the type of deformity. If the acetabulum is well developed, a wedge resection of the base of the neck, correcting the anteversion, is sufficient. If the acetabulum is well developed but does not hold the head of the femur, a more prominent roof of the acetabulum is to be obtained by operation; and, simultaneously, a wedge resection of the base of the neck is performed to correct the valgus and the anteversion.

If the acetabulum is completely insufficient, the author recommends its reconstruction and also a derotation osteotomy, if anteversion is present; or a wedge osteotomy of the base of the neck if there is valgus in addition to the anteversion.

The author warns against neglecting the treatment of subluxation on one side, if there is a coexisting complete dislocation on the other side.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

TREATMENT OF FRACTURES OF THE TIBIAL CONDYLES. Robert A. Knight. *Southern Medical Journal*, XXXVIII, 246, 1945.

This series reports 134 cases of fractures of the tibial condyles, eighty-one treated conservatively, and fifty-three by operation. Conservative treatment is used when there is only moderate displacement, and not more than one-fourth-inch depression of the condyle. After reduction of the fracture and aspi-

ration of the joint, if distended, a plaster cast is applied for three weeks, followed by active motion and physiotherapy for three more weeks. Then a knee brace is applied, but weight-bearing is not allowed for ten weeks. Operative treatment is used, if there is appreciable depression of the articular surface. The cruciate ligaments, or collateral ligaments, may have to be repaired. The incision should be large enough to explore the joint cavity. The meniscus may have to be removed. After the depressed condyle has been elevated, a bone graft is necessary to hold it up in place. Internal pin fixation holds the graft and fracture in place. Cancellous bone taken from the femoral condyle makes an excellent graft. Malunited fractures are treated by osteotomy and bone graft.

Postoperative care includes a plaster spica with the knee slightly flexed. In two or three weeks, after the wound has healed, the cast is removed, and the leg is suspended in balanced traction for active and passive motion. Daily physical therapy is given, the patient being instructed in quadriceps exercises, and care is taken to prevent forcible flexion of the knee. After five or six weeks a long leg brace with limited motion at the knee joint is applied. Partial weight-bearing is begun after eight or ten weeks. Full weight-bearing is started after five or six months. The period of disability following operation in the cases in this series averaged seven to ten months.

Traumatic arthritis has been found to develop after a varying period of years in many instances following operative reconstruction of the tibial condyles.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

TRENCH FOOT. Frank K. Boland, Jr., Thomas S. Claiborne, and Francis P. Parker. *Surgery*, XVII, 564, 1945.

During the winter months in France, Belgium, and northern Italy many of our soldiers suffered from trench foot. This condition was manifested by pain and swelling of the feet, following exposure for long periods of time to wet and cold. The authors of this article report observations based upon the study of 125 of these patients at a general hospital.

The pathology of trench foot is quite similar to that of frostbite, immersion foot, shelter foot, and chilblain. The average time of continuous exposure to cold and wet by the men in this group was eleven days. Dry cold was much better tolerated than moist cold approximately at the point of freezing. Very few of the men had opportunity to change their socks during the period of their exposure, and the socks were usually wet. The swelling was more marked when the patients removed their shoes and their feet became warm. Simultaneously the pain increased.

Treatment consisted simply of elevation of the feet, which were kept dry and moderately cold. The covers were kept turned back in most instances. When pain and swelling had diminished, some exercises were encouraged. In the severe type, gangrene developed; and necrotic tissue had to be cut away. Eighty-two per cent. of these patients were able to return to duty after a period of treatment and convalescent care which averaged sixty-one days.—*Edward L. Compere, M.D., Chicago, Illinois.*

HOMOGENOUS CARTILAGE GRAFTS. Forrest Young. *Surgery*, XVII, 616, 1945.

This study was undertaken to determine the viability of various types of cartilage transplants. In a previous experimental study by the author, autogenous cartilage grafts were used and dogs were selected for the experiments. It was found that autogenous costal cartilage, when transplanted to the subcutaneous tissues in dogs, remained viable, and did not lose weight or volume for as long as one and a half years. It made no difference whether the cartilage was transplanted with or without perichondrium. Following these experiments, the author was able to examine an autogenous costal cartilage graft which had been used in the treatment of a woman for a nasal deformity twelve years previously. Microscopically, the cartilage appeared normal.

In this study, Young transplanted segments of costal cartilage from one dog to the abdominal wall of another; five pairs of dogs were used. A total of sixty pieces of costal cartilage were implanted in the abdominal walls of ten dogs; in each instance the cartilage was obtained from a donor dog. These grafts were removed at intervals and examined. A few of the cells had lost their nuclei, and a central area of bone formation had appeared in some of the cartilage grafts. The cross transplants, however, all remained viable, though some degenerative changes were present. —*Edward L. Compere, M.D., Chicago, Illinois.*

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